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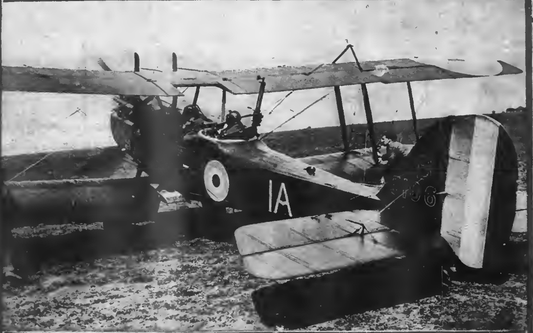

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THE GARDNER, MOFFAT CO., Inc.
120 W. 32nd ST. NEW YORK

Entered as second-class matter, August 2, 1916, at the


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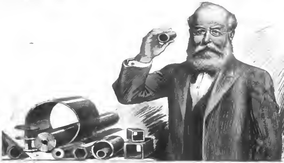

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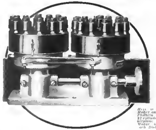

Here is shown the Contact Maker and Distributors of the Philbrin System devised for 12 cylinder double ignition airplane motors. A Contact Maker is contained within each Distributor

For Airplanes

The double ignition airplane motor presents a problem of spark synchronism which has found its solution in Philbrin Triplex Double Airplane Ignition

This system is specially designed for double ignition motors. The current for both distributors is fed through one Contact Maker

In other words, one Contact Maker **SIMULTANEOUSLY** fires both spark plugs in each cylinder. Thus perfect synchronism is assured

Each spark is completely efficient and will continue so at all engine speeds and under highest compression. There is no speed that the engine can attain for which the Philbrin Contact Maker has not ample capacity. Due to inherent simplicity of design the Philbrin Contact Maker operates **WITH PRACTICALLY NO LAG**

The Philbrin Triplex Double System embodies **THREE** separate systems of motor ignition—two virtually independent Single Spark Systems and one High Frequency or Emergency System. Each Single Spark System has its Contact Maker located within one of the Distributors. Only one Contact Maker serves at a time. The other is always available by turning a switch

The High Frequency System employs a magnetic interruptor, delivering a "shower of sparks" to each cylinder through the same pair of Distributors. This "shower of sparks" will fire any mixture that is ignitable. It has special value in case of emergency and provides efficient combustion under conditions such as—a flooded carburetor, fouled plugs, a chilled motor, or inferior fuel.

This combination of three systems makes ignition failure practically impossible. It would be hard to conceive of an ignition system more adequately suited to airplane requirements

Tests have been made of Philbrin Triplex Double Ignition on double ignition motors and the results of these tests should be of genuine interest to airplane engineers. They are available to responsible parties.

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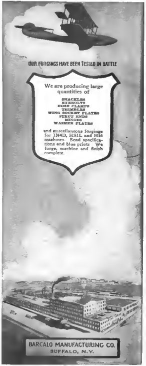

AUGUST 1, 1918 VOL. V. NO. 1

AVIATION AND AERONAUTICAL ENGINEERING

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THE GARDNER - MOFFAT COMPANY, Inc., *Publishers*

120 WEST 32D STREET, NEW YORK

WASHINGTON OFFICE, 310 EVENING STAR BUILDING

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ISSUED ON THE FIRST AND FIFTEENTH OF EACH MONTH FORMS CLOSE FIVE DAYS PREVIOUSLY ENTERED AS SECOND-CLASS MATTER, AUGUST 3, 1916, AT THE POST OFFICE AT NEW YORK, N. Y., UNDER ACT OF MARCH 3 1879

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Vol V August 1, 1918 No.1

Conventional Propeller Calculations

By F W. Caldwell*

Under war conditions, when there is lack of time for extensive propeller trials and experimental work, we must be able to predict the performance of a propeller as to the horsepower absorbed at given airplane and engine speeds and as to its efficiency under these conditions It is also necessary to make stress calculations for the purpose of predicting strength,

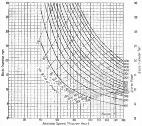


FIG 1 CHART FOR DETERMINING PROPELLER DIAMETERS FOR 15 PER CENT SLIP ALSO MAXIMUM PROPELLER SPEEDS FOR GIVEN DIAMETERS AND HORSEPOWERS

since there is usually no opportunity for a destructive test before the propeller has to be put into production The main purpose of this paper is to show how such calculations are made

FIG 1A PROPELLER EFFICIENCY AT VARIOUS SPEEDS OF FLIGHT

The first step is to choose a diameter The chart, Fig 1, shows the minimum diameter required to maintain the slip as low as 15 per cent The chart also shows the maximum propeller speed that can be used for any given diameter and horsepower If the speed is greater than that shown as the maximum, a smaller diameter must be chosen for the propeller, and there is a consequent loss in efficiency

The diameters given are minimum diameters for good practice. In general the diameter should be made as large as possible without making the blades so narrow that they will flutter excessively when wood construction is used Plane designers should bear in mind the necessity of ample propeller diameter in laying out a power plant installation, as otherwise excellent design may be spoiled by limitations of clearance, resulting in too small a propeller diameter

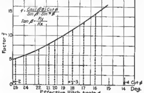


FIG 1B VALUES OF FACTOR f FOR VARIOUS EFFECTIVE PROPELLER PITCH ANGLES

After determining the diameter, a blade form must be chosen The question of the outline of the blade form is an unsettled one, since different blade forms are based on elaborate theories. The difference in efficiency of different blade forms is not great, but the difference in strength is considerable The form shown in Fig 2 is a fair one, both as to efficiency and strength.

The following nomenclature relating to propeller design will be used in this paper

FIG 2 EXPERIMENTAL BLADE FORM

ρ = specific weight of air expressed in pounds per cubic foot.
g = acceleration due to gravity = 32.2 f p.s.
K_y = lift coefficient, absolute units
K_x = drag (or drift) coefficient, absolute units.
L = vertical component of force (lift) on aerofoil, pounds.
D = horizontal component of force (drag) on aerofoil, pounds.
f = factor for computing work absorbed by propeller
C = empirical constant depending on blade form
S = area of plane surface, square feet.
V = velocity of airplane, feet per second.
P_e = effective pitch of propeller or advance per turn.
V_1 = velocity (in helical path) of propeller element, feet per second
v = velocity of slip stream, feet per second.
b = maximum blade width, feet.

*Aeronautical Mechanical Engineer, Aviation Section, Signal Corps, U S Army Paper read before S A E Convention at Dayton

= effective blade width ... = 0.75b for blade form in Fig 2.
N = engine speed at ground level, rev per second
N_1 = engine speed at 20,000 ft altitude, rev per second
d = diameter of propeller, feet
D = equivalent diameter of propeller, feet = 0.580d (for computing work absorbed only)
R = radius of propeller, feet
T = thrust, pounds.
A = area of propeller disk, square feet
A_1 = effective area of propeller disk, square feet $\left(= 0.95\pi \frac{d^2}{4}\right)$ (as corrected for the 5 per cent area considered ineffective due to the radiator)

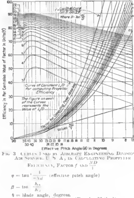


FIG. 3 CURVES USED BY AIRCRAFT ENGINEERING DIVISION OF AIR SERVICE, U. S. A., IN CALCULATING PROPELLER EFFICIENCY, FACTOR f AND $\frac{ND}{V}$

$\varphi = \tan^{-1}\frac{V}{\pi Nd}$ (effective pitch angle)

$\beta = \tan^{-1}\frac{K_x}{K_y}$

θ = blade angle, degrees.
e_t = theoretical efficiency (Froude Method), per cent $\left(= \frac{100V}{V + v/2}\right)$
e_a = aerofoil efficiency, per cent
e = true efficiency, per cent ($= e_t \times e_a$)

It is necessary to solve for blade width and angle of attack by means of an empirical formula. As a rough rule the angle of attack may be taken as 2 deg. for plane speeds above 100 m.p.h. and 3 deg. for plane speeds below 100 m.p.h. The method of checking this would go beyond the scope of this paper, which is intended to cover only fundamentals.

The maximum blade width should be about one-twelfth the diameter for the best practice. This gives an "aspect ratio" of six for each blade.

The usual method of computing blade widths consists in dividing the blade into zones and treating each zone as a separate aerofoil. The power absorbed by each zone is then found from the formula

$$\text{Work for zone} = \frac{\rho}{g} K_x S V_r^3 \qquad (2)$$

This may be simplified by taking an average value of K_x for the blade and a weighted mean for the blade width. The power absorbed per blade is then found from the formula.

$$\text{Power} = \frac{\rho}{g} K_x b_1 R V^3 f C \text{ ft lb per sec} \qquad (3)$$

The value of f may be obtained by taking 0.58 of the diameter to represent an equivalent diameter for the whole blade. (This value has been established experimentally for blade form shown in Fig. 2.) Then the value of $V/0.58\pi Nd$ is calculated, as is the corresponding angle whose tangent is $V/0.58\pi Nd$, and the corresponding value of f is found on the chart, Fig. 3.

The ordinate corresponding to the angle is followed until it crosses the line corresponding to an L/D of the section, and the corresponding value of f is read on the scale at the right or left. An average value of L/D may be assumed with sufficient precision to be twenty, when using this method.

The empirical constant C is dependent on the blade form and must be determined experimentally. For the blade form shown in Fig. 2 it is 1.1, while it varies from 0.85 to 1.2 for different blade forms now in use. The symbol b_1 represents the weighted mean of the blade width. This weighted mean of the blade width is found by determining the mean ordinate of a curve in which the cubes of the radii of the blades sections are laid off as abscissae and the corresponding blade widths are laid off as ordinates. This empirical method gives good results.

The best method of computing propeller efficiency consists in an extension of the water-propeller theories. The theoretical efficiency $V/(V + v/2)$ is computed. First the thrust is computed and then the slip-stream velocity from the impact formula $T = \frac{\rho}{g} AVv$.

To compute the aerofoil efficiency a representative point along the blade is taken. This will usually be at 75 or 80 per cent of the radius according to the blade shape; for the blade shown in Fig. 2 it is at about 78 per cent. The product of the theoretical and aerofoil efficiencies gives the actual efficiency very closely. There is a further small correction due to the spiral component of the slip stream.

The angle whose tangent is $V/0.78\pi Nd$ is found and a corresponding ordinate φ, Fig. 3, is followed until it crosses the efficiency line corresponding to the L/D of the aerofoil section at 0.78 of the radius. This L/D will be about twenty in good design.

Propeller Materials

Wood has been the favorite propeller material up to the present. Its success is mainly due to its high tensile strength, light weight and flexibility. Flexibility is an important factor in reducing propeller stresses, as can be seen from Figs. 4 to 6. When the thrust is applied to a wooden propeller, the blade bends and the centrifugal force creates a moment tending to restore it to its original position.

FIGS. 4, 5, 6 DEFLECTIONS CAUSED BY AXIAL THRUST AND CENTRIFUGAL FORCE. ALSO CROSS-SECTIONAL VIEW OF BLADE

The lack of flexibility is evidently one of the weaknesses of steel propellers, since the metal cannot bend and accommodate itself to the different flying attitudes. This difficulty can be overcome for any single flying attitude and air density by offsetting centers of gravity of different sections in such a way that the bending moment due to air pressure is compensated for by the bending moment due to centrifugal force.

A few photographs of steel-propeller failures are reproduced as Figs. 7 to 14. None of these propellers was carefully designed, so that the failures occurred after a few minutes' running at comparatively low speeds. All of these propellers were heavier than the wood propellers designed for the same service, and in none of them was the strength of the same order of magnitude as in the wood propellers. We have repeatedly tested wood propellers at speeds up to 2500 r.p.m. without injury.

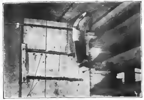


FIG. 7 VIEW AFTER FAILURE OF PROPELLER WITH STEEL BLADE EMBEDDED IN ROOF
A—Observers slats

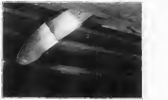


FIG. 11 PROPELLER BLADE EMBEDDED IN ROOF AFTER FAILURE
This propeller consisted of two steel plates riveted to a forged hub. Destroyed after five min. at 1800 r.p.m.

FIG. 8 PARTS OF PROPELLER SHOWN IN FIG. 7
A—Hub bolts sheared 0.065 in. sheet steel hub. Destroyed after 2 min. at 1330 r.p.m. B—Rubber packing. C—Bare spool. D—Rubber in hub. E—Balance hole. F—Riveted edges

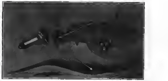
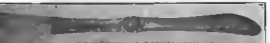
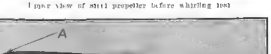


FIG. 12 PARTS OF PROPELLER SHOWN IN FIG. 11
A—Hub uninjured. B—All rivets failed in double shear. C—Shaft broke. D—Oval rivet sheared



Upper view of steel propeller before whirling test



Lower view shows opening (A) at seam at leading edge. Failure after 14 min. at 1400 r.p.m. A piece welded inside from blade for balancing flew out of the tip.

FIGS. 9 AND 10

Among the propeller materials experimented with up to date the metals have shown the least encouraging results. While I do not consider a steel propeller out of the question, it is certain that the results to date have been discouraging. Steel propellers should be given a thorough ground test before being used in flight on an airplane, since the failures are usually extremely sudden and are disastrous to the plane structure.

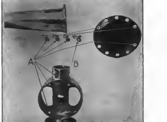


FIG. 13 HUB PARTS OF STEEL PROPELLER AFTER FAILURE, BLADES UNINJURED
A—Three bolts failed. B—One of five bolts uninjured.

Aerofoils

The aerofoil sections used have an important bearing on the propeller efficiency. The characteristics shown in Figs. 15 to 17 are taken from a report issued in 1912 by the National Physical Laboratory of England, and are about as good as any that have been published.

Adjustable-Pitch Propellers

Almost from the start of air propeller work, a propeller with adjustable pitch has been considered highly desirable, because it is believed that the efficiency of the propeller could then be maintained constant for different airplane speeds. This is based on the theory that the L/D of the aerofoil section is the controlling factor in the propeller efficiency, a theory which is not borne out in practice.

Fig. 14 Blade of Similar Propeller, Cracked at A

Fig. 18 illustrates the effect of varying plane speed on the apparent angle of attack of a propeller section. This angle is usually chosen as 2 deg. for a flight speed of 130 m.p.h. and the aerofoil will then have a ratio of K_y/K_x of about twenty. In climbing at the rate of 70 m.p.h. the apparent angle of attack will be increased to about 10 deg., and the K_y/K_x ratio will drop to from ten to twelve.

Fig. 19 shows that the increase in true angle of attack is not so great when the slip stream velocity is taken into account; besides this, the theoretical efficiency $(V/V+v/2)$ is greatly reduced in climbing and is not increased by an increase in the aerofoil efficiency.

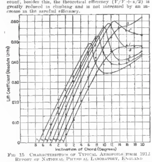


Fig. 15 Characteristics of Typical Aerofoils from 1912 Report of National Physical Laboratory, England

An analysis of an adjustable pitch propeller (appended to this paper) shows no gain in efficiency. There is, however, a net gain in horsepower delivered to the plane, owing to the increase of engine speed in climbing. For the case in question the gain in the rate of climb is 49 per cent. Fig. 20 shows the gain in the rate of climb in a somewhat slower machine.

The keeping up of the engine speed becomes of interest in connection with the development of an engine with torque that is constant at high and low altitudes. From the performance curves shown in Fig. 21 it is apparent that the climbing rate of a plane equipped with such an engine would be greatly improved if the engine speed near the ground were increased and kept the same as the plane climbs.

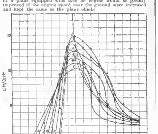


Fig. 16

It is the opinion of the author that, if it becomes desirable, an adjustable pitch propeller of fairly light weight can be built for a smooth running engine, such as the Liberty twelve,

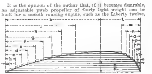
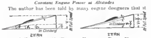


Fig. 17

but considerable trouble may be expected with engines that have an inherent vibration.

Constant Engine Power at Altitudes

The author has been told by many engine designers that it



Figs. 18 (Left) and 19 (Right) Effect of Plane Velocity on Angle of Attack

would be useless to build an engine to maintain its power at altitudes, because the propeller efficiency would then be so low that the net gain would be small.

All aeronautical engineers who have made a study of the subject realize that the development of an engine with constant, or nearly constant torque at altitudes up to 20,000 or 30,000 ft., is the one outstanding opportunity for improvement in airplane performance. It is just as easy to design propellers for operation at 20,000 ft. as it is to design them for performance at the ground level, so that the problem is one that must be solved by the engine designers.

The air density at 20,000 ft. is of the order of 50 per cent of that at ground level. The density of air is about 0.13 per cent of the density of water. Yet we are using the same means of propulsion in airplanes as is used in boats, and we are obtaining in practice efficiencies as high as 85 per cent, something which cannot be approached in marine practice. Not only is this true, but a propeller designed for use at 20,000

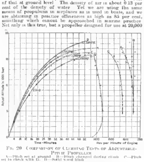


Fig. 20 Comparison of Climbing Tests of Adjustable-Pitch Propeller

A—Pitch set at ground. B—Pitch changed during climb. C—Pitch set to check with B. D—Solid wood blade

ft. will function without appreciable loss of efficiency near the ground, as may be seen from an analysis in which airplane and propeller performance are worked out in a typical case.

The words "constant torque" as used in the following analysis mean that the torque is independent of both the engine speed and the altitude. This is the simplest case to discuss, and the discussion applies exactly to this case alone. An engine that satisfies this requirement only in part would, of course, have a performance intermediate between that of the conventional gasoline engine and that of the engine with constant torque. This analysis is applicable equally to a steam turbine and is perhaps of more interest in relation to a steam turbine, owing to the range of speed involved.

In comparing the performance of the airplane and propeller at 20,000 ft. altitude and at the ground, we will assume:

1. Speed of airplane at ground level, 130 m.p.h., or 191 f.p.s.
2. Output of engine, 356 hp. (at 1400 r.p.m., or 23.3 r.p.s.)
3. Diameter of propeller, 11.5 ft. (area 104 sq. ft.)
4. Total lifting surface of plane, $S = 420$ sq. ft.
5. Total weight of loaded plane, $W = 3400$ lb.

The value of K_y in absolute units is computed from the formula

$$W = \frac{\rho K_y S V^2}{g} \tag{4}$$

$$K_y = \frac{3400}{0.00238 \times 420 \times 191^2} = 0.0933 \tag{5}$$

The corresponding value of K_y/K_x may be taken as 12.3.

The efficiency of the propeller can be computed by a method of trial as follows: First assume an efficiency of 80 per cent. The thrust will then be

$$T = \frac{0.80 \times 356 \times 550}{191} = 820 \tag{6}$$

The slip stream velocity can be computed from the impact formula (2), and then

$$v = \frac{T}{AV\frac{\rho}{g}} = \frac{820}{104 \times 191 \times 0.00238} = 17.3 \text{ f.p.s.} \tag{7}$$

which means that the slip is 9 per cent.

From the Froude method the theoretical efficiency can be found as follows:

$$e = \frac{1}{1+\frac{v}{2}} = \frac{191}{200} = 0.955 \tag{8}$$

Analysis of Propeller Efficiency

Assuming that the section at 0.75 radius is representative of the propeller as a whole and that the value of L/D at this section is twenty, the efficiency by the aerofoil method can be obtained from the chart shown in Fig. 3. It is first necessary to find the corresponding value of Nd/V, which is

$$\frac{Nd}{V} = \frac{1400}{60} \times \frac{0.75 \times 11.5}{210} = 1.01 \tag{9}$$

The aerofoil efficiency is found from Fig. 3 to be 85 per cent. The product of the two efficiencies (see equation 8) is $0.955 \times 0.85 = 81$ per cent. A further correction due to the spiral component of the slip stream will reduce this to 80 per cent. Since the assumption made in computing the slip-stream velocity was correct it need not be recomputed.

The drag of the supporting surfaces at ground level and at

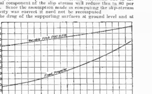


Fig. 21 Performance of Propeller for Constant Torque Engine

a plane velocity of 191 f.p.s. will then be $3400 \div 12.3 = 276$ pounds. The parasite resistance, that is to say, the propeller thrust minus the wing drag will be $820 - 276 = 544$ pounds.

At 20,000 ft. altitude the air density can be taken as 56 per cent of the density at ground level. As a first approximation assume that the propeller speed will vary in proportion to the cube root of the horsepower, the horsepower being proportional to the engine speed (if constant torque is assumed), and in inverse proportion to the cube root of the density, then in level flight

$$N_1 = 23.3 \sqrt[3]{\frac{N_1}{23.3} \times \frac{1}{0.5}} = 33 \text{ r.p.s.} = 1980 \text{ r.p.m.} \tag{10}$$

Assuming a constant torque the engine will then deliver 503 hp. Assuming 80 per cent propeller efficiency

$$T = \frac{503 \times 0.80 \times 550}{V} = \frac{221{,}500}{V}$$

As a first approximation to determine K_y, assume the velocity to be proportional to the cube root of the horsepower delivered and inversely proportional to the cube root of the air density. Then

$$V = 191 \sqrt[3]{\frac{1}{0.5} \times \frac{503}{356}} = 270 \text{ f.p.s.}$$

$$\text{and } K_y = \frac{3400}{420 \times 0.00119 \times 270^2} = 0.0933$$

The corresponding K_y/K_x will be 12.3 and K_x will be 0.00759.

$$\text{Thrust} = \text{Total Drag} = \left(\frac{\rho}{g} K_x S V^2\right) + \left(\frac{0.5}{1} \times 544 \times \frac{191^2}{191^2}\right)$$

Since $\frac{\rho}{g} = 0.00119$ at 20,000 ft. altitude, we have

$$\frac{221{,}500}{V} = \left(0.00119 \times 0.00759 \times 420 + \frac{0.5 \times 544}{191^2}\right) V^2$$

Whence

$$V = 270 \text{ f.p.s.} = 184 \text{ m.p.h.}$$

Thus the assumptions as to plane velocity are seen to be correct for constant torque, so that they need not be recomputed

To find the propeller efficiency under the new condition the thrust is first computed from the formula

$$T = \frac{550 \text{ hp} \times e}{V} = \frac{550 \times 503 \times 0.80}{270} = 820 \text{ lb}$$

Again the slip-stream velocity will be

$$v = \frac{T}{AV\frac{\rho}{g}} = \frac{820}{104 \times 270 \times 0.00119} = 24.3 \text{ f.p.s.}$$

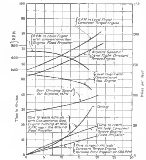


FIG 22 CLIMBING AND LEVEL FLYING PERFORMANCE OF AIRPLANE WITH CONSTANT TORQUE ENGINE COMPARED WITH THAT OF PLANE WITH CONVENTIONAL GAS ENGINE

The theoretical efficiency will be

$$e = \frac{V}{V + \frac{v}{2}} = \frac{270}{270 + 12} = 0.958$$

Since Nd/V has the same value as before, the true angle of attack will be the same and the aerofoil efficiency will again be equal to 85 per cent.

The product of the two will as before be 81 per cent, and this will be reduced to 80 per cent by the correction for the spiral component of the slip stream

It is apparent therefore that the efficiency of the propeller is the same for the two flying conditions, provided the engine torque is kept constant.

These results can be deduced without making the calculations as follows The total lift of the plane may be expressed as

$$W = \frac{g}{\rho} K_y S V^2$$

in which S is constant for all altitudes and W and g are approximately constant In order to maintain a constant angle of attack K_y must be held constant, then ρV^2 is constant, and V is inversely proportional to the square root of the density For this condition the total drag of the machine will remain constant and the horsepower required to drive the plane will be equal to the horsepower required at the ground level multiplied by the ratio of the plane velocity at altitude to the plane velocity at the ground

If the speed of the propeller is kept proportional to the velocity of the plane, its N/d and its efficiency will be constant. To maintain this speed the engine horsepower must be proportional to the ratio of N^3 multiplied by the inverse ratio

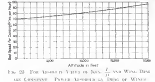


FIG 23 FOR ABSOLUTE VALUES OF KEY $\frac{L}{D}$ AND WING DRAG ARE CONSTANT POWER ABSORBED BY DRAG OF WINGS WILL THEN BE PROPORTIONAL TO SPEED OF PLANE

of the air densities But since N^3 is proportional to V^3 it is also inversely proportional to the ratio of air densities It is consequently necessary to maintain only the engine horsepower proportional to the speed This is obviously the definition of an engine with constant torque

The rate of climb to be expected from a plane fitted with a constant torque engine is shown graphically in Fig 21

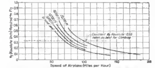


FIG 24 PROPELLER FOR CONSTANT TORQUE ENGINE BEST CLIMBING SPEED AT GROUND LEVEL 70 M P H

If an adjustable-pitch propeller were applied to this engine, the propeller speed could be maintained at 1700 r p m during the whole climb The horsepower available and the rate of climb, Figs. 22 and 23, indicate such an improvement in the performance that the variable pitch feature becomes highly desirable

Ceilings

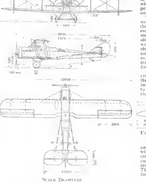
Evidently the ceiling of such a plane is not limited by aerodynamical considerations, but only by the strength of the materials employed The engine and propeller speed would continue to increase until something let go The limiting speed of a propeller of this size would probably be about 2500 r p m in thin air with the materials now in use. This would correspond to an air density equal to 31 per cent of that at the ground, and at an altitude of about 34,000 ft In flying at greater heights it would be necessary to throttle the engine in order not to over-stress the propeller, so that the ceiling would be in the neighborhood of 45,000 feet

In conclusion I wish to emphasize the fact that the variable-patch propeller is, to a certain extent, limited to special cases. The design of a propeller for an engine with constant torque presents no difficulty, except that the climbing rate near the ground must be reduced, owing to the slow speed of the engine. This is not serious and can be entirely overcome by the use of a variable-pitch propeller The interesting feature of this development is the great speed to be expected. It is not out of the question to attain speeds of 200 m.p.h. at an altitude of 30,000 feet

The De Haviland-IV Biplane*

This large airplane employed for long distance reconnaissance and for bomb dropping, is chiefly built by the Aircraft Manufacturing Co, Ltd. (England) The different machines show minor differences in construction and outfitting according to the time of construction

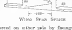
Both wings of the two strutter biplane, which have distinctly rounded tips, have a span of 12.93 m and a chord of 1.67 m



SCALE DRAWINGS

The stagger is 0.32 m There is no sweep-back, but the upper and lower planes are attached respectively to a center section 0.7 m wide and direct to the body, at a dihedral angle of 1¾ deg The pilot, whose seat is right under the top plane center section, has a good view forward The center section and wings have their trailing portions cut away in the center to give a better view backwards The angle of incidence is 3 deg at the body and at the top plane center section Both main spars, which are of spruce, are of one section, left solid where occur the compression ribs At these points and where fittings occur the spars are not only left solid but are reinforced by mahogany pieces glued and screwed on At a point between the inner inter-plane struts and the commencement of the wing flaps the main wing spars are spliced and bound with fabric

The wing ribs are only very slightly cambered on the under surface Leading and trailing edges are slightly raised. Into grooves in the two flanges, which measure 13 mm in width and 4.5 mm in thickness, are glued and tacked with brass tacks the three-ply webs, which are provided with large lightening holes. The ribs at the struts and in the middle of each bay have flanges as wide as 37 mm, and the web between them is solid spruce between the spars. Between every two ribs, which are spaced 310 to 400 mm apart, there is a false rib extending from the leading edge to the front spar The internal wing bracing, which is of thickened wire, is in duplicate up to the middle of the outer bay The wing covering is of a yellowish-white color, and is sewn to the ribs in such a way that the stitches surround the whole rib. In front of the trailing edge, which is in the form of a strip of wood, eyelets are incorporated in the under surface, which serve to equalize pressure and to drain out moisture



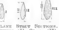
WING SPAR SPLICE

The crank levers of the wing flaps, which in all the planes are hinged direct to the rear spars, are made of 1.5 mm. sheet aluminum, which is reinforced on either side by facings of wood riveted on The same construction is employed for the elevator and rudder cranks. At their outer end, where the control cables are attached, the aluminum cranks are doubled over The very simply arranged wing bracing consists of stream line wire, while the external drift bracing takes the form of cables

The wing fittings are, as in so many other English machines, very simply carried out. Three mm thick sheet steel plates at the outer plane struts, and 3 mm and 2 mm. at the inner struts, having lugs bent to the angle of the bracing wires, are secured to the wing spars by two bolts. A large forked bolt passes through the center of the spar while a second smaller one

UPPER AND LOWER WING SECTION DISTANCE BETWEEN RIBS UPPER, 310 TO 380 MM LOWER, 310 TO 400 MM

passes down the outside of the spar The interplane struts, which are made of spruce, are of streamline section, and the inner struts are kept stronger than the outer ones. On the ends of the struts are short sheet steel shoes into which are riveted aluminum packing pieces hollowed out in the center Through these are passed 8 mm. steel bolts, which rest in the forked end of the spar bolts, the bracing wires keeping the



PLANE STRUT SECTIONS. CENTER (I), OUTER (II), INNER (III)

UPPER AND LOWER SPAR SECTIONS

struts in place The struts for the top plane center section are similarly attached.

The body is covered with ply-wood up to a point behind the gunner's cockpit, this part being built up without the use of diagonal bracing The longitudinals are of spruce and the engine bearers of ash The formers as well as supports for controls and machine guns are made of ply-wood, some of which is 14-ply and as much as 26 mm. thick. The fittings for the attachment of the lift wires are each connected with two 8 mm through-bolts The after portion of the body is carried out in the usual manner as a girder, and the longitudinals are spliced This does not apply to the extreme rear part underneath the tail plane, which is covered with ply wood 3 mm thick In the front the body has a rounded top From the observer's seat vertical formers gradually carry the

* Translation of an article in *Flugsport*, reproduced by courtesy of *Flight*

top into the rectangular section of the beginning of the tail plane

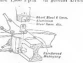
The undercarriage is very light in proportion to the heavy machine. It weighs 54 kg Each pair of struts is of solid wood and is not bound with fabric. Screwed to the struts are vertical strut-shoes of wood, which carry, in addition to the wheel axle, horizontal tubes for the attachment of the rubber shock absorbers. The axle rests between two cross struts of wood, which are shaped to a fair shape and connected at the bottom by 4 mm three-ply. In order to cause no eddies during the flight the axle is fitted into the streamline casing thus formed by covering its upper side with a layer

Tail Plane and Elevator Tail Plane Front Spar, 42 mm., Rear Spar, 50 mm.

of wood suitably hollowed out and secured to it with a wrapping of fabric. In order to better guide the axle in the slots in the struts this casing of wood is left square at this point, and entirely surrounds the axle It is covered with sheet metal The diagonal bracing of the undercarriage is in the form of streamline wire, and is only placed in the bay of the front chassis struts. In addition there is a horizontal tension wire running in front of the streamline cross-strut

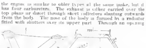
The tail plane, which is of rectangular plan form with rounded corners, is so attached to the body that its angle of incidence can be varied from the pilot's seat, during flight, from + 2 deg to + 5 deg, as in the Sopwith. For this purpose its front spar is so mounted as to be free to rotate while the rear spar with its bracing is secured to a vertical tube placed in front of the stern post This tube carries a thread engaging with an internally threaded bobbin, bolted to the stern post but free to rotate, operated by a hand wheel and cables, and forcing by its rotation the thread, and with it the vertical tube, up or down. The two elevator flaps, hinged to the tail plane, are not connected to one another The rudder has a balanced portion

The 12-cylinder Rolls Royce engine develops, according to the firm's plate on it, 300 hp at 1,650 r p m., when the hourly consumption is 105 liters of gasoline and 4 5 liters of oil. The speed is not to exceed 1,800 r p m In general arrangement



Interplane Strut Attachment

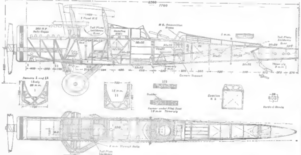
the engine is similar to other types of the same make, but it has four carbureters. The exhaust is either carried over the top plane or direct through short collectors slanting outwards from the body The nose of the body is formed by a radiator fitted with shutters over its upper part Through an opening



The Undercarriage

in the centre of the radiator projects the reduction gear of the engine, which reduces the speed of the airscrew to 900 r.p m.

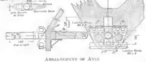
Under the front of the body is placed transversely the oil



Scale Drawing of the Body Wing Area Top Plane, Including Flaps 20 69 sq m, Lower Plane, Including Flaps, 19.62 sq.m. Total Wing Area 40·31 sq m. Airscrew Diameter, 2.68 m Blade Width, 0 145 m Pitch, 3 30 m Contents of Radiator, 35 Liters

tank, which has a capacity of 21 liters The main gasoline tank, which is arranged for air pressure, has a capacity of 256 liters and is placed behind the pilot's seat. A gravity tank holding 28 liters is placed under the left top plane Sufficient fuel is carried for a flight of about 2¾ hours' duration In another machine there is an additional tank holding 76 liters, which brings the capacity up to about 3¾ hours.

More recent machines have, instead of the one pressure tank and mounted in the same place, two tanks placed side by side, each of which is provided with a supply pump driven by a small propeller With this arrangement a spring-loaded valve is provided inside the tank, which returns any surplus of gasoline to the tank The two leads from the main tanks

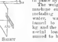


Arrangement of Axle

and that of the gravity tank are joined at the engine to an omnibus tube, to which is attached a manometer for controlling the tanks.

The machine is provided with complete dual control, the control lever of the observer being removable The wing flaps are interconnected and their cables run on the outside of the wings along the leading edge Each wing flap has two crank levers The upper and lower flaps are connected by two streamline wires. In the same manner the elevator and rudder cables run on the outside of the body, the rudder cables being in duplicate, while each of the elevator flaps has single control cables

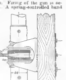
The equipment of the pilot's and observer's cockpits differs in individual machines On an instrument board in the former, provided with illumination for night flying, are the following instruments speed indicator, revolution counter, altimeter thermometer, clock, hand pressure pump, inclinometer, map board and compass To the left of the pilot the various gasoline pipes are so arranged that the different cocks are within easy reach On the same side are arranged oil and gasoline pressure indicators, a pressure pump, fed from the gravity tank, and also on a common axis the throttle, spark, advance lever, and mixture regulator for altitude work On the throttle rods a catch lever is so arranged that when the throttle is closed the lever for regulating the mixture at altitudes will return with it To the right of the pilot are arranged the cables controlling the radiator shutters, the switch for night illumination, and shelf for signal cartridges Gasoline level indicators are not fitted



Bomb Sight

In the observer's cockpit are placed Speed indicator, altimeter, throttle and switch for night illumination. Observer's and pilot's cockpits are placed far apart on account of the main gasoline tanks being placed between them. For communication between the occupants there is a speaking tube on the right, and on the left an endless cable passing over rollers in the two cockpits Behind the observer's seat is the mounting for the camera with adjoining shelves for the slides The presence of a wireless outfit could not be ascertained in any of the machines

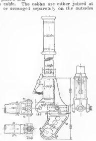
The armament consists of two interconnected machine guns mounted on a turntable in the observer's cockpit, and of a fixed machine gun for the pilot mounted on the left of the top covering of the body The control of the fixed machine gun is accomplished hydraulically by a control mechanism placed immediately behind the airscrew This mechanism is driven off a pinion on the hub of the airscrew, and releases two shots for each revolution of the airscrew Firing of the gun is accomplished from the control lever A spring-controlled hand pump for filling the leads is mounted on the floor of the pilot's cockpit For loading there is either a lever on the gun or a cable running over a roller, provided with a grip A telescopic sight is placed to the right under the gun, in front of the rectangular wind screen. As the observer's seat is placed rather far aft, a good field of fire is also obtained from here in an outward and forward direction.



Tail Plane Incidence Gear

The bomb gear, judging from the makeshift way in which the release gear is built, appears to have been added as an afterthought. Bomb racks, either arranged for four smaller or for one large bomb, are placed under the lower wings and under the body The release is accomplished from the pilot's seat by means of Bowden cable. The cables are either joined at the right of the seat or arranged separately on the outsides of the body A sighting arrangement is built into the body immediately behind the rudder bar It consists of a square plano-concave glass plate, 15 mm. thick at the edges and 5 mm. thick in the center Underneath this are three wire rods soldered at right angles to a fourth rod lying in the direction of flight, while 17 cm further down is another longitudinal rod, and a transverse rod working in longitudinal slots, which can be locked in place by screws.

The weight of the machine empty, but including cooling water, was ascertained to be 1,110 kg and the maximum useful load is assumed to be 590 kg.



Control Lever in the Observer's Cockpit

Weights

	Kg
Engine	390 0
Exhaust pipes	17.0
Radiator and water	76 0
Airscrew	42 0
Gasoline tanks	28 0
Oil tank	4.0
Engine accessories leads etc	16 0
Body with cowl	175.0
Tail plane incidence gear	2 0
Body accessories, seats etc	6 0
Undercarriage	54.0
Tail skid	5 0
Controls	9 0
Wings	209 0
Bracing	31 0
Armament supports	40 0
	1110 0

Loads

	Kg
Crew	150 0
Armament	72.8
12 bombs, about	144 0
Photographic outfit	10 0
Wireless arrangement	5 0
Fuel	205 0
Estimated useful load	590 0
Weight of wings	5 2 kg sq m.

Determination of Permeability of Balloon Fabrics*

By Junius David Edwards

1—Introduction

One of the most essential characteristics of a balloon envelope is that it shall be gas tight, or nearly so. Therefore the determination of the permeability of balloon fabrics to hydrogen, which is the gas used in the modern dirigible and kite balloons, is of first importance in determining their suitability for balloon construction. In connection with a study of the permeability of balloon fabrics it has been necessary to investigate different forms of apparatus and the influence of experimental conditions in order to interpret test results intelligently. The results of the Bureau's investigation of methods of determining permeability are presented in this paper. The affect of composition, method of construction, etc., upon the permeability will not be discussed in the present paper, which deals only with testing methods.

A great many materials have been suggested for rendering fabrics gas tight, the great majority of balloon envelopes, however, are made from rubber-coated silk or cotton, usually the latter. For the balloon envelope, two plies of cloth are used with the gas-tight rubber film between them. The two plies may be placed parallel to each other or one ply may be placed at an angle of 45 deg., the biased fabric is supposed to offer greater resistance to tearing. Usually from 100 to 130 grams of rubber per square meter are placed between the plies. For protecting the fabric and the gas retaining rubber film from the action of light, heat, moisture, etc., rubber coatings may be applied on the outside, further protection is sometimes added by coating the inside of the fabric also. Lighter single-ply fabrics are sometimes made for use in ballonets and three-ply fabrics find use in large dirigibles or supply balloons.

Goldbeater's skin finds some application in dirigible balloons of the rigid type. Oiled fabrics of various kinds, as well as fabrics coated with lacquers made from cellulose acetate or nitrate, have been tried. Various coatings have also been applied to rubberized fabrics with a view to rendering them more nearly gas tight and increasing their durability. However, none of these has been found entirely successful.

2—Theory of Permeability Process

Gas escapes from a balloon envelope through leaks at valves, seams, and imperfections in the fabric, and by passage through the fabric. Hydrogen might pass through the fabric by diffusion through minute holes in a manner similar to the passage of a gas through a porous plate or it might escape by solution in the rubber film with subsequent evaporation from the other side. As a matter of fact, both processes occur simultaneously. The escape of hydrogen through openings in the fabric is only a case of gas effusion, but the passage of hydrogen through the rubber of the fabric is a very different phenomenon.

Thomas Graham,[1] in 1866, investigated the flow of gases through rubber films and showed that it was a solution phenomenon and not a diffusion phenomenon. If gases passed through rubber films by diffusion through microscopic holes, their relative rates of escape should be approximately inversely proportional to the square roots of their densities. Graham showed, however, that the rates of penetration of different gases bore no relation to their density. He found the relative rates of penetration of rubber by different gases to be as follows

Nitrogen	1.0
Methane	2.15
Oxygen	2.56
Hydrogen	5.5
Carbon dioxide	13.59

The rate of change of permeability of rubber films with change of temperature is also much greater than can be accounted for by the diffusion theory. These and other facts have shown that gases penetrate rubber by first dissolving in the rubber.

When a rubber-coated balloon fabric is placed in contact with hydrogen on one side and air on the other, the following process is substantially what occurs. Both the hydrogen and the oxygen and nitrogen of the air dissolve in the rubber film and tend to saturate it up to the limits determined by the temperature and by the partial pressure of each gas. Each gas penetrates the rubber film at its characteristic speed, and when it reaches the opposite side of the rubber film the gas evaporates from its solution in the rubber because the partial pressure of the gas in question is substantially zero. More of each gas is dissolved continuously on the first side of the fabric and a dynamic equilibrium is reached which continues so long as fresh air and fresh hydrogen are available at the two surfaces. In this manner hydrogen passes through the rubber to the air side and air passes through to the hydrogen side.

These facts will be discussed more fully in connection with the experimental work and their bearing on methods of test pointed out.

3—Methods of Determining Permeability

The permeability of a balloon fabric may be defined as the rate at which it is penetrated by a certain gas, except when stated otherwise, this gas is understood in this paper to be hydrogen. Permeability will be expressed in terms of liters of hydrogen per square meter per 24 hr., the volume of hydrogen being corrected to the standard conditions of 0 deg. C and 760 mm. mercury pressure.

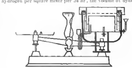


FIG 1 RENARD-SURCOUF BALANCE

The methods in use for the determination of the permeability of balloon fabrics to hydrogen may be divided into two classes (1) Methods which measure the rate of decrease in volume of a mass of hydrogen separated from the atmosphere by a definite area of the fabric, or (2) methods which measure by chemical or physical means the volume of hydrogen passing through a definite area of fabric in a given period.

The two methods may be characterized as the volume loss and penetration methods, respectively. According to the definition of permeability just given the volume-loss method does not measure the permeability of a fabric because in the volume loss method the quantity measured is the volume of hydrogen escaping minus the volume of air passing into the hydrogen chamber. What it measures is the difference in the permeability of the fabric to hydrogen and air. Accordingly, any result obtained with this method will be characterized as the "volume-loss" permeability.

(a) *Volume Loss Methods.*—The most widely used apparatus for applying the volume-loss method is known as the Renard-Surcouf balance. As shown in Fig 1, it consists of the bell of a small gas holder mounted on one arm of a balance; the top of the bell is closed by the fabric (shown by a dotted line) under test. The bell moves up and down in an annular space filled with water, the annular container is attached to the base of the balance. The bell is first filled with hydrogen by alternately filling and emptying until the air has been displaced. The proper pressure is then obtained by adding weights to the opposite balance arm. As hydrogen escapes, the bell sinks, and the pointer moves over a calibrated scale indicating the volume loss. The apparatus should be kept in a constant temperature chamber.

Five other forms of apparatus of this class are described by Austerweil[2]. In each of these forms of apparatus a gas chamber filled with hydrogen is closed by the fabric under test. A graduated measuring tube is connected with this chamber and the volume of hydrogen escaping is measured by the volume of water necessary to replace it and maintain constant pressure. A leveling bottle may be used to introduce water into the measuring tube or it may be connected with a Mariotte flask which automatically introduces the water under constant pressure. If a leveling bottle is used, the pressure does not remain constant and must be adjusted at frequent intervals. The operating characteristics of this class of apparatus are discussed in section 6.

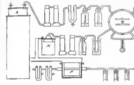


FIG 2 APPARATUS OF BARR AND ROSENHAIN

(b) *Penetration Methods.*—The various forms of apparatus for applying the penetration method all employ a cell which is divided by the fabric into two chambers. In one of these chambers an atmosphere of hydrogen is maintained at a definite pressure. Through the other chamber is passed a stream of air which carries away the hydrogen as it penetrates the fabric. The amount of this hydrogen is determined by burning it to form water and weighing the water after absorption in some suitable medium, or the percentage of hydrogen is determined in the stream of air passing over the fabric by means of the gas interferometer.

The apparatus of Barr and Rosenhain,[3] as used in the National Physical Laboratory, is shown in Fig 2. The hydrogen from the electrolytic cell K passes through a series of washing and drying tubes into the permeability cell G and out through the water seal H. The air from the gas holder A after passing through a series of washing and drying tubes passes over the other side of the fabric, then through another series of drying tubes, through an electric furnace F, where the hydrogen is burned, and finally through the absorption tubes C and D which are to be weighed. The permeability cell is kept in a constant temperature bath.

The apparatus described by Heyn[4] and used at the Physikalischen Reichsanstalt is similar in principle though differing in form and detail.

Frenzel[5] made a notable improvement in this method by employing a Rayleigh-Zeiss gas interferometer for determining the concentration of hydrogen in the air stream after passing over the fabric. From the percentage of hydrogen as determined and the rate at which the air was passing, as determined by a gas meter, the permeability was easily calculated.

4—Experimental Apparatus

In the investigation of different testing methods several forms of apparatus were employed. The most useful apparatus and the one employed in all routine testing work as well as most of the experimental work is shown in Fig 3. It applies the penetration method and employs a gas interferometer for determining the hydrogen passing through the fabric.

In this apparatus, the fabric is held in the permeability cell a, maintained at constant temperature in an air or water bath h. Pure, dry hydrogen passes over one side of the fabric and out through a water seal g.

Air after passing through the wet-pressure regulator c and a length of capillary tubing to reduce pressure fluctuations, is dried by bubbling through concentrated sulphuric acid in e and then passed over the other side of the fabric through a drying tube d' and into one chamber of the interferometer. It passes out through the drying tube d'', which prevents diffusion of water vapor into the interferometer and then through the saturator f filled with glass beads partly covered with water and then through the wet meter m. The saturator is employed to prevent loss of water from the meter by evaporation into the gas being measured. When the interferometer is being read, the air stream is by-passed through the cock l into the wet meter so as not to interrupt the flow of air through the permeability cell. The pressure on the air and hydrogen sides is measured by U-gages i filled with oil and water, respectively. Dry air is passed through the other chamber of the interferometer to serve as a comparison gas, or it may be passed through both chambers when it is desired to obtain the "zero reading" of the interferometer.

The gas interferometer and its uses have been described in detail by Haber and Lowe,[6] L. Stuckert,[7] L. H. Adams,[8] and others. The Rayleigh-Zeiss type of gas interferometer measures the difference in refractivity of two samples of gas contained in two gas chambers 100 cm long. Light from an illuminated slit passes through both chambers, after which the two beams combine to produce interference fringes which are observed through an eyepiece. The optical paths of the two beams can be brought to equality by tilting a glass compensator plate which is placed in the path of one of the beams. If the composition of the gas in one of the chambers is changed, the optical paths are different and the interference fringes are shifted. The fringes are brought back to their original position by tilting the compensator plate. The angle through which the compensator plate has been turned, which is measured by means of a drum attached to the micrometer screw, is a measure of the change in refractive index of the gas.

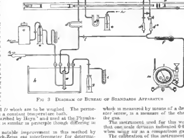


FIG 3 DIAGRAM OF BUREAU OF STANDARDS APPARATUS

The instrument used for this work was of such sensitivity that one scale division indicated 0.01 per cent hydrogen in air when using air as a comparison gas.

The calibration of this instrument by a new method has been discussed by the author[9] in the Journal of the American

* Published by permission of the Director Bureau of Standards.

[1] Phil Mag 32, p. 401 1866

[2] G Austerweil Die Angewandte Chemie in der Luftfahrt. Published by R Oldenbourg München 1914

[3] Report of the British Advisory Committee for Aeronautics, p 88, 1909 10

[4] Sitz. der König Akad Wiss. p 385 1911

[5] "Über die Gasdurchlässigkeit der Gummierten Ballonstoffe" Zs. für Flugtechnik und Motorluftschiffahrt, 5 p 264 1914

[6] Haber and Lowe Zs f Angew Chem. 23, p. 1393, 1910

[7] Stuckert, Zs f Elektrochemie 16 p 37 1910

[8] L. H Adams J Am Chem Soc., 37 p 1181, 1915

[9] Edwards J Am Chem Soc. 39 p 2382 1917

Chemical Society. The interferometer furnishes a rapid and accurate method of determining the amount of hydrogen penetrating the fabric. Its many advantages will be pointed out in connection with the various subjects discussed in succeeding sections.

The permeability cells used are shown in greater detail in Fig 4. The cell adopted as standard had a fabric area of 250 cm^2; other cells having areas of 1000, 100, 50 and 25

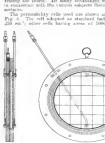


Fig 4 Bureau of Standards Permeability Cell

cm^2 were constructed for experimental purposes. In designing these cells the gas and air chambers were kept small in volume in order to reduce the space which must be swept out when operating. A large mesh wire screen (3 cm openings) kept the fabric from being pressed against the back of the air chamber by the pressure of the hydrogen. The flanges of the cell contain a number of very fine grooves which take up the excess of grease used to make the fabric gas tight; they also give a better grip on the fabric. The two halves of the cell are held together by bolts and wing nuts (not shown in figure).

Connections to the gas and air lines and interferometer were made with small metal unions, and copper and glass tubing was used in making the connections to the various parts of the apparatus where necessary.

5—*Effect of Experimental Conditions on Apparent Permeability*

In order to interpret tests made under different conditions and with different apparatus, the effect of experimental conditions on the apparent permeability was investigated. The apparatus shown in Fig 3, with various modifications, was used for all the work reported in this section. The general conclusions reached are applicable to all apparatus of this type whether the hydrogen is determined by combustion or by use of an interferometer; the operating detail of the apparatus, however, may be quite different. The interferometer was used in preference to the combustion method because it greatly facilitated the testing work in point of speed and accuracy and permitted the carrying out of certain experiments which would otherwise have been impossible of execution.

(a) *Effect of Temperature on Permeability*.—It has been known for a long time that the permeability of rubber films increases rapidly with increase of temperature.[10] For this reason it is necessary in all accurate work to maintain the fabric at a constant temperature during the period of test.

The rate of change of permeability with change of temperature for a number of different fabrics is shown in Fig 5. In determining these curves the cell containing the fabric was mounted in an air bath, which was maintained at the desired temperature by means of an electric heater controlled by a thermostat. The fabric was allowed to come to equilibrium and its permeability determined at each temperature before changing to the next temperature. Curves 10449, 10451 and 10650 show the temperature coefficients of fabrics from three American manufacturers and curve 10568 is for a fabric of foreign manufacture. These curves are all very similar in shape, indicating that, approximately at least, the same relation between permeability and temperature holds for fabrics of quite different composition. For purposes of comparison, another curve showing the change of permeability with temperature as determined by other experimenters is included. This curve A is taken from the report of Gibbons and Smith,[11] it shows substantial agreement with the Bureau's results. Frenzel[12] gives graphs for four continental balloon fabrics. They show a smaller rate of change than any of the preceding curves and indicate the change of permeability to be a linear function. None of the fabrics examined by this Bureau have shown a linear relation between temperature and permeability. Communications from private testing laboratories here and abroad show temperature effects corresponding to those obtained at the Bureau and do not indicate a linear relation. Two tests at two different temperatures by Rosenhain and Barr[13] indicate a somewhat more rapid increase of permeability with increase of temperature. Their data are insufficient to warrant any general conclusions, however.

In order to make the tests comparable, the Bureau of Standards has adopted the practice of making all tests at a standard temperature of 25° C. This temperature was adopted because of the ease and convenience with which the testing apparatus could be maintained at this temperature, and because it was thought to represent with some degree of approximation an average balloon temperature.

The National Physical Laboratory, England, has adopted 15.5° C (60° F) as its standard temperature. That temperature cannot be maintained in most American testing laboratories in summer without refrigeration, which needlessly complicates the testing. The customary practice in France is to use 15° C as the standard temperature. However, temperature control of the Renard Surcouf balance, which is the most widely used instrument there, is rather difficult and it is not known what degree of uniformity there is in temperature control in French practice. For the purpose of approximate comparisons, the permeability of the average rubberized fabric at 15° C may be taken as 65 per cent of the permeability at 25° C.

(b) *Effect of Pressure on Permeability*.—It has been customary, both here and abroad, to determine the permeability of balloon fabrics under a pressure of hydrogen equivalent to 30 mm of water. This is approximately the normal working pressure of a non-rigid balloon.

The pressure coefficient for two-ply balloon fabrics has been found to be rather small. The rate of change of permeability with change of hydrogen pressure for three fabrics is shown in Fig. 6. The change in permeability with change in pressure is very small, above 50 or 60 mm the curve being almost horizontal. The greater effect of pressure change at low pressures may be due, as suggested by Frenzel, to the fact that the initial increases of pressure stretch both the rubber film and the supporting fabric, but the point is soon reached where further stretch of the rubber film is prevented by the relatively inelastic fabric, and thereafter the permeability shows only a very small change. The effect of pressure as well as of temperature varies somewhat with different fabrics, but with those tested it was small. This is to be expected, since an increase of hydrogen pressure of 10 mm of water (0.74 mm of mercury) means an increase of only about 0.1 per cent in the total pressure of the hydrogen.

Since the permeability is approximately proportional to the partial pressure of hydrogen, the permeability should vary with the atmospheric pressure, because the partial pressure of the hydrogen is equal to the atmospheric pressure plus the constant excess pressure under which it is confined in the cell. However, the changes in barometric pressure are usually small, seldom more than 1.5 per cent; accordingly, they have been neglected in routine testing since their effect upon permeability, as far as can be ascertained from an examination of test results, is within the limits of experimental error. It should be noted that it is the excess gas pressure above atmospheric

[10] Graham Phil Mag 32, p 401 1866

[11] First Annual Report of the National Advisory Committee for Aeronautics (Washington, 1915), p 171.

[12] Frenzel "Über die Gasdurchlässigkeit der Ballonstoffe." Druckerei des Elsässischen Textilblattes im Gebweiler

[13] Report Great Britain Committee on Aeronautics p 60 1910 11

which produces the greatest part of the increase noted at the beginning of the curves shown in Fig 6.

(c) *Effect of Humidity of Hydrogen and Air*.—The influence of moisture upon the permeability was determined by

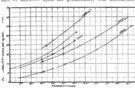


Fig 5 Effect of Pressure on Permeability

comparing the permeability shown when using dry hydrogen and air with the permeability when using moist hydrogen and air. When dry gas was to be used, it was passed through concentrated sulphuric acid; when moist gas was employed, it was passed through sulphuric acid of such concentration that the relative humidity of the saturated gas was approximately 65 per cent at 25° C.

The permeability of a fabric was determined with dry gas and then with moist gas; the order was then reversed. The same difference was noted in each case when testing under the two different conditions. The average results of these tests are given in Table 1.

TABLE 1.—EFFECT OF HUMIDITY OF HYDROGEN AND AIR ON PERMEABILITY

Order of test	Condition of hydrogen and air	Permeability liters per square meter per 24 hours	Difference
First test	Wet	13.8	
Second test	Dry	14.4	0.6
First test	Dry	15.1	
Second test	Wet	14.5	0.6
First test	Wet	13.7	
Second test	Dry	14.5	0.8
First test	Dry	14.6	
Second test	Wet.	13.9	0.7

When the hydrogen is 65 per cent saturated at 25° C there is approximately a 2 per cent decrease in the partial pressure of the hydrogen due to the addition of water vapor. This partially explains why a 4 to 5 per cent decrease in permeability was noted when changing from dry gas to wet gas. The amount of water dissolved in the rubber probably also influences the rate of penetration of the rubber by the hydrogen.

Tests showed that the moisture contained in the fabric was not completely removed by a current of dry air at 25° C after a number of hours' passage, so that it is certain that the rubber compounds under the conditions of test with dry gas still contain an appreciable amount of water vapor.

No further experiments on the effect of moisture were made, since it was evident that the difference in permeability under the two conditions of test was small—less than 1 liter in this case. For testing purposes the conditions of test which are recommended should be easily obtained and duplicated, and it is obvious that the use of dry hydrogen and air is most satisfactory in every respect. It does not introduce further complications in calculations and testing, and gives results very close to those obtained with partially saturated gas.

(d) *Effect of Volatile Substances in Fabric*.—The apparent permeability may be affected by the removal of volatile substances from the fabric by the current of air passing over it. There may be present in the air stream after passing over the fabric varying amounts of water vapor, carbon dioxide, or the vapor of benzol, gasoline, or other solvent used in the manufacture, in addition to the hydrogen which has penetrated the fabric. The water vapor and carbon dioxide which may have been dissolved in the rubber are removed by soda lime and calcium chloride before the air stream enters the interferometer. In case the combustion method is used, only the water vapor need be absorbed.

The presence of vapor of solvents, however, introduces a possible serious source of error into either method. If the hydrogen is estimated by use of the interferometer, the apparent permeability is too low, because the refractivity of solvent naphtha or benzol is higher than the refractivity of air or hydrogen. If the combustion method is used, the results are too high by the amount of water formed by the combustion of the solvent. This point should be carefully considered when testing fabrics of very recent manufacture, and it is of great importance in the commercial control of fabric manufacture. It is usually assumed that the solvent used in the rubber coatings when they are spread is entirely removed by the subsequent heating and curing. In some cases, notably three-ply fabrics with heavy rubber coatings, sufficient solvent may be

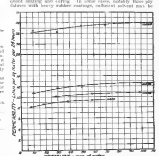


Fig 6 Effect of Pressure on Permeability

left to seriously vitiate test results unless it is removed or corrected for. Its presence can usually be detected from the odor of the fabric.

The necessary correction for solvent vapor can be readily found by determining the reading of the interferometer when using air in place of hydrogen in the permeability cell. Since the amount of solvent given off by the fabric decreases with time, it is necessary to take at least three readings at short intervals to determine the rate of change of the blank, the correction at the time of the permeability test, which should follow immediately, is estimated by extrapolation. This method does not necessitate waiting for the complete removal of the solvent before beginning the test, and for most purposes is sufficiently accurate. It is of course obvious that a more accurate method would be to wait until the solvent is completely removed, thus eliminating the necessity for a blank correction.

The estimation of the blank correction is more difficult in case the combustion method is used, because it is impracticable to determine its rate of change. Its magnitude may be determined, however, and if a more accurate determination is required, a number of permeability tests can be made at suitable intervals.

Of several hundred samples tested at the Bureau only fabrics of a certain composition have shown blanks of appreciable magnitude. The possibility should not be overlooked, however, in the case of any fabric with heavy rubber coating and of very recent manufacture, particularly if the presence of solvent can be detected by the odor.

(To be concluded)

The Roland D.II Biplane*

This single-seater pursuit biplane made its first appearance on the Western front in March, 1917, and is still being used to some extent by the enemy, particularly on the Eastern sectors. A description of this machine, therefore, appears to be of timely interest.

The overall dimensions of the Roland D.II biplane are rather small, as may be seen from the following table:

Span of upper wings	8.90 m.
Span of lower wings	8.50 m.
Overall length	6.95 m.
Overall height	2.95 m.

Its weight, gross, that is, fully loaded, is 827 kg., which is slightly greater than that of the Albatros D.III pursuit biplane. The wing area being 23 sq. m., the wing loading consequently is 36 kg. per sq. m.

The Body—The construction and shape of the body deserve special attention. The body is of the monocoque type and of

View of Body Ridge and Radiators

oval cross-section, which ends at the rear in a vertical knife-edge. The construction is throughout excessively light, the body being built up of thin longitudinals bent to suit the curvature of the stream-line, and light bulkheads, only four of which are situated between the pilot cockpit and the tail.

As a matter of fact, the longitudinals act only in the capacity of stringers or distance pieces, for the body derives its rigidity entirely from its plating of veneer; this is built in two halves and is joined at the top and bottom of the body. The veneer plating consists of six ply wood and is covered on its outer side with fabric, its total thickness is only 1.5 mm.

Between the pilot cockpit and the engine the body is tapered out upward until it forms a vertical ridge of 0.11 m. width, to which the upper wings are attached. The latter are partly hollowed out in the center for letting in the radiator. The lower wings are attached to wing roots integrally built with the body. A wooden tail skid, steel-shod, is fixed at the rear end of the body, its hinge being protected by a steel sheet casing.

The pilot is seated very high in the body, but even so his field of vision is not very good, because it is divided by the central ridge.

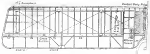
The Wings—The wings are of trapezoidal shape, without

Wing Section

stagger or dihedral, but have a sweepback of 1½ deg. The upper and lower wings have both a chord of 1.45 m., and the gap is throughout the entire span 1.34 m.

The ribs are set perpendicular to the leading edge, and, as both members of a pair of interplane struts are attached to the same rib, it follows that, owing to the sweepback of the wings, the two struts of each pair are offset relative to the axis of flight.

The upper wings are built up of two spruce spars, situated 0.83 m. from one another, the front spar being 0.13 m. from the leading edge, and twelve ribs of gray poplar, with ash flanges. The ribs are spaced 0.37 m. and are divided by false ribs of 10 mm. thickness, which are fixed between the leading edge and the rear spar. Four compression members of steel tubing are fitted between the front and rear spars and are spaced 1.30 m. The inter spar wiring consists of 3 mm. piano wire, and the steel tubes are 25 mm. in diameter. The wing structure is further strengthened by suitable wooden corner blocks and stout fabric straps, which alternately pass over and under the ribs, two of these straps are carried between the



Detail Drawing of Upper Port Wing

leading edge and the front spar, and two more are situated between the wing spars.

Non balanced ailerons are carried on the upper wings, the aileron hinges are protected by a covering of veneer, which is fixed underneath the wing fabric. At its leading edge, that is, near the rear wing spar, the aileron has a span of 1.82 m. and a chord of 0.43 m. The aileron axle is a tube of 30 mm. diameter. The aileron cranks are operated by vertical, tubular rods, like on the Nieuport scout.

Q. D. Wing Bolt

Besides the radiator, which is inset in the center portion of the upper wings, as has been said before, an emergency tank, conforming in shape to the wing curve, is carried on the upper port wing.

The upper wings are fixed to the peak of the body ridge, which supersedes on this machine the classic cabane, by means of quick detachable bolts of a system similar to that used in the L. V. G. model C.IV biplane.†

The framework of the lower wings is similar to that of the upper wings, the spacing of the wing spars is the same, but there are only ten ribs, nine of which are 10 mm. wide, while the tenth, nearest to the tips, is 25 mm. wide. The same false ribs, of 10 mm. width, occur here as on the upper wings, and the wire bracing is also the same, but the tubular compression struts between the wing spars are of smaller cross-section and are spaced differently. The outermost tube is 20 mm. in section, while the three remaining compression members are 25 mm. tubes, counting from the wing tips these tubes are spaced 1.17 m., 1.13 m. and 1.11 m., respectively. As has been said before, the lower wings are attached to wing roots built out of the body.

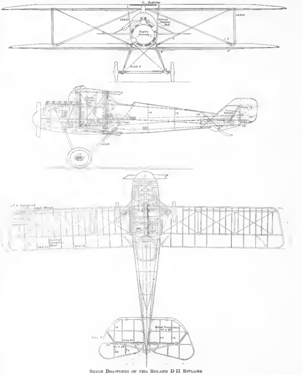
Both wings are slightly washed out, the angle of incidence being 4 deg. at the second rib and 3 deg. at the seventh rib.

The interplane struts are constituted of 25 mm. steel tubes stream lined with wooden fairings, their depth being thus brought up to 90 mm.

The Tail—The tail has, roughly, a trapezoidal outline, with, at the rear end, a triangular cut-out for affording play to the rudder. The framework of the stabilizer is of wood, while that of the elevators is constituted of steel tubing. The elevators are balanced by triangular portions.

* Translated from *L'Aérophile*.

† See the June 15 1918 issue of Aviation



Scale Drawings of the Roland D II Biplane

The method of attachment of the tail plane is worthy of particular interest, the leading edge of the stabilizer is hollowed out and fits into a horizontal cross-piece which is fixed inside of the body, and extends 0.50 m on either side. This arrangement imparts to the tail plane a great amount of rigidity, which is further increased by two tubular struts which brace the trailing edge of the stabilizer to the stern post.

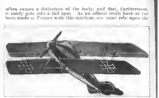
The vertical fin is built integrally with the body and is, as the latter, covered with veneer plating. The rudder embodies a triangular balanced portion, and is built up of light steel tubing. The control cables are carried inside of the body up to a point about 1 m from the stern post.

The Power Plant—The engine is a 6-cylinder, 160 hp Mercedes, which is fitted with a horizontal exhaust collector, carried out on the starboard side. In addition to the emergency tank above mentioned, which is carried on the upper port wing, a main fuel tank is fitted underneath the pilot's seat. On the model examined the airscrew was broken and could not, therefore, be identified, it was fitted with a spinner.

Armament—This consists of two Spandau machine guns, which are synchronized with the engine. They are mounted on either side of the latter, and are, but for their extremities entirely covered by the central ridge of the body.

Undercarriage—The undercarriage is of the V-type, with a continuous axle, which is sprung by Sandows and is carried in a stream-line casing. The V-struts are steel tubes, which abut on the body against the base of two inclined body bulkheads. The track is 1.75 m, and the wheels are 760 x 100.

It is said of the Roland D-II that its very light construction often causes a distortion of the body, and that, furthermore, it easily gets into a tail spin. As no official trials have so far been made in France with this machine, one must rely upon the



Three-Quarter Front View

judgment of the aviators who have fought it to gain a fair opinion on the flight performances of the Roland D II. It thus appears that this machine is listed among the best enemy pursuit machines, and though its conception, entirely novel at the time, dates back to over a year, the Roland D II is still employed in certain enemy pursuit squadrons.

Cost of the Air Mail Service

The first tabulated report on the operation and maintenance of the air mail service has just been released by Otto Praeger second assistant postmaster-general, and is printed in the accompanying tables. The report covers the period from the start of the service, on May 15, to the end of that month.

As may be seen in Table I, nine airplanes were at the time employed in the service, the first six being Curtiss JN-4H machines, fitted with 150 hp Hispano-Suiza engines, while the three last were Curtiss R-4 biplanes fitted with 350 hp Liberty engines. Since all these machines are the property of the Army Air Service, the Post Office made no charge for depreciation as to their cost.

In the report no account is taken of the very important item of depreciation because no convincing data are said to be available on this subject, nor are any data furnished concerning the wear to which the machines have been subjected or their age at the time of starting the service. The items of rent, light, power, miscellaneous expenditures, dead time of pilots and hangar men, shop time of mechanics and departmental overhead charges, all of which are not directly apportionable to individual machines, are prorated equally between all airplanes. Whether it would have been more satisfactory for determining the actual work done to apportion these items in proportion to the mileage made by each machine is a question that only cost accountants could settle.

With reference to Table II, it may be noted that the three mail planes fitted with Liberty engines averaged a higher cost per hour and per mile, with lower miles run per gallon of gasoline, than the machines fitted with Hispano-Suiza engines.

Thus was, of course, to be expected, since the Curtiss R-4 is a much larger machine than the JN-4H model, and the Liberty-12 is much more powerful than the 150 hp Hispano-Suiza.

A careful study of the appended tables may develop many interesting points, and should give to those interested in the development of commercial aeronautics the first reliable data on which to base the cost of operating an air mail service.

TABLE I

Airplane No	Gas	Grease and Oil	Office Force	Mail Trucks	Rent Light Power Telephone and Water	Misc	Pilots: Actual Time	Pilots: Dead Time	Hangar Men: On Plane	Hangar Men: Miscellaneous	Mechanics: On Plane	Mechanics: Shop Time	Repairs and Accessories	Depreciation and Interest	Departmental Overhead Charge	Total
37994	$13 75	$7 71	$11 73	$12 40	$22 00	$2 66	$26 68	$21 73	$6 35	$9 72	$102 30	$8 72	$9 77	$37 56	$16 60	$338 10
38262	20 92	4 78	11 73	12 40	22 06	2 66	16 92	21 73	1 95	9 72	141 87	11 62	128 30	47 56	16 60	321 03
38274	77 15	21 43	11 72	12 40	22 06	2 66	41 20	21 73	2 00	9 72	140 13	11 62	11 62	31 40	16 60	451 59
38273	77 49	25 46	11 72	12 40	22 06	2 66	65 70	21 73	1 87	9 72	167 65	9 72	142 71	42 56	16 60	617 35
38276	34 37	10 32	11 73	12 40	22 06	2 66	66 30	21 73	1 87	9 72	122 43	9 72	27 98	31 56	16 60	437 51
38270	57 50	20 66	11 73	12 40	22 06	2 66	66 25	21 74	19 03	9 72	187 47	9 72	31 78	22 56	16 60	347 57
38268	27 60	3 56	11 73	12 39	22 07	2 66	14 54	21 74	6 75	9 72	68 98	9 72	5 42	27 56	16 60	263 40
38267	22 80	4 38	11 72	12 39	22 07	2 67	13 27	21 74	1 87	8 73	34 87	8 73	4 22	27 57	16 72	234 75
Totals	$405 38	$67 87	$105 56	$111 [illegible]	$166 57	$23 66	$309 40	$181 60	$46 24	$77 76	$1150 15	$87 50	$304 87	$248 65	$118 00	$3682 11

It will be of special interest to the Post Office authorities if readers of AVIATION AND AERONAUTICAL ENGINEERING will make suggestions as to how cost data may be expressed in a possibly more accurate manner, and how depreciation should be figured, so that a more truthful representation of the actual cost of commercial air mileage may be obtained.

TABLE II
SERVICE AND UNIT COST

Airplane No	Gal of Gas	Total time run (hr)	Total time run (min)	Total miles run	Miles run per gal of gas	Cost per hour	Cost per mile
37994	92	7	16	550	5 98	$40 66	$0.5449
38262	71	11	56	838	1 38	27 38	1.3624
38274	298	13	06	1345	5 29	25 06	.3353
38273	362	16	24	1247	4 75	31 85	.4982
38276	104	15	40	1024	5 32	28 56	.4270
38270	245	26	40	1711	7 01	26 01	.4343
38268	85	5	06	380	7 01	67 93	.9497
38267	124	3	26	540	4 33	47 59	.3099
38287	76	3	51	270	3 55	73 70	.7990
Totals	1377	113	a	7234	5 30	$32 54	$ 5090

Skilled Workmen May Be Retained

The Government is coming to the assistance of contractors on aircraft manufacture by enabling them to retain the services of skilled workmen who may have been drafted or who enlisted. As the labor shortage is now one of the most difficult problems facing both the Government and the manufacturers the following letters and forms will be found of not a little importance to all persons engaged in aircraft production.

WAR DEPARTMENT
OFFICE OF DIRECTOR OF AIRCRAFT PRODUCTION, WASHINGTON
Personnel Department

From Office of the Director of Aircraft Production
To All Contractors
Subject Loss of skilled men by draft or enlistment

1 For the purpose of assisting this office to cooperate with you in your labor problems, you are requested to fill out and return, at your earliest convenience, Forms FR1-11 and 11-a enclosed.

2. It is believed that the forms are self-explanatory. You are advised, however, that indefinite furloughs can probably be obtained for any of your skilled or technical employes heretofore drafted, in accordance with the explanation provided on Form 5 also enclosed. You are requested to bring this matter to the attention of all your sub-contractors and to cause them to communicate with this office if they desire.

Please note that in addition to checking on Forms 11 and 11 a the names of men whose return is desired, you must also fill out complete application blank in each case, as per sample attached. Additional application blanks will be sent you on receipt of a request for a stated number. When requesting such blanks, please bear in mind that an original and two copies must be furnished this office in each separate case.

4 Frequent report is made to this office through Recruit Depots in various parts of the country that skilled workmen have been drafted without a request for their release or furlough having been made by their employers. Such men can be furloughed and assigned to any plant in need of men of their respective qualifications. It is requested that you advise this office if, in the event that the names of any such men are ascertained, they may be furloughed and ordered to report for duty to you and if you are prepared to receive and give them employment on short notice. It must be borne in mind that this office cannot concern itself with the comparative excellence of the men, but it is believed that in view of the existing shortage of labor, you may be in a position to employ, without reservation, such skilled men as may be available in this manner.

Form FRI-5—Indefinite Furloughs

WAR DEPARTMENT
BUREAU OF AIRCRAFT PRODUCTION, WASHINGTON
Personnel Department
From Office of the Director of Aircraft Production
To
Subject Return of employees to necessary industry

1 In reference to your communication of you are advised that it is now impracticable for this office (formerly the Equipment Division of the Signal Corps) to take action to secure deferred classification for any of your employees.

2 In the event, however, that any of your skilled or technical employees are actually drafted and inducted into service, their return to you may be obtained in accordance with the following procedure.

3 Separate application for each employee must be forwarded in triplicate (i. e. one original and two carbons including all signatures) on Form FRI 1 of which a supply is furnished herewith. This application must be checked and verified by a representative of this Bureau (i. e. a Government inspector or commissioned officer) at or near your plant) or if this is impossible by a city, county or state official having knowledge of the facts.

4 This application should be forwarded to this office as soon as you know the camp or recruit depot to which the individual concerned has been sent, and no action will be taken on any application in which the exact location of the man is not accurately stated. You should arrange to have the man furnish you this information by telegraph, if necessary at the earliest possible moment.

5. An indefinite furlough without pay or allowances will then be requested for the man concerned and if this is granted the man will be ordered to report to you to resume his former occupation. He may wear the uniform if he so desires or may wear civilian clothing but in either case he will be paid and treated in all respects by you as though he had never been drafted.

6. The Adjutant General's Office will notify you the day the man's Commanding Officer is instructed to furlough him. Telegraphic report must be made to this office on the day on which each such furloughed man reports to you. The form of this telegram will be "(full name of man) on furlough reported for duty today (name of organization)."

7 On the last day of each subsequent month a further report must be made by you to this office as to the continuation and character of each such furloughed man's employment. Forms for this report will be furnished you. Failure to make the report will result in the immediate termination of the furlough.

8. If at any time, any employee so furloughed and returned to you leaves his employment or ceases to be indispensable, you will instantly telegraph this office, the Commanding General of your department and Office of The Adjutant General of the Army, Washington, D C, as follows:

(full name of man) who was furloughed and returned to this organization on (date) has left our employ (or has ceased to be indispensable). His last known address is (address of man.)"

Forms to Be Filled Out

FORM FRI-11

RETURN THIS FORM TO
OFFICE OF DIRECTOR OF AIRCRAFT PRODUCTION, PERSONNEL DEPARTMENT WASHINGTON, D C.
Date

Name of organization
P O Address Location of main plant
Location of other plants
Exact nature of industry
Approximate percentage of output going to United States Government or Allies directly indirectly
We now have the following shortages of skilled labor (specify number of men actually short in each kind of job)
No of men between 21 and 31
No of men between 21 and 30
No. of men between 18 and 30
No of men between 18 and 45
No. of men over 45
Total No. of men employed
Total No of women employed
To maintain schedules of expected production on Government work, we need the following number of skilled or technical employees (state actual number required in each trade)

FORM FRI 11A

LIST OF SKILLED MEN LOST BY DRAFT OR ENLISTMENT
By
Located at

Name of Man	Present Rank	Company	Detachment	Camp and Location	Former Position	If return is needed mark X and file application on Form FRI 1.

APPLICATION BLANK—FORM 1

When properly filled out in duplicate, mail this blank to
Washington, D C

APPLICATION FOR RETURN OF ENLISTED MAN IN HIGHLY SKILLED CLASS OF LABOR TO "NECESSARY" INDUSTRY

Dated at 191 .

Application is hereby made for the return of following enlisted man:
Name Residence
Exact description of trade
Registered Local Board Order No. Serial No
Last reported to Camp Unit
Taken into Army 191 , because
We ask that he be directed to report to

We have the following direct Government Contracts
Date Gov Order No Quantity Description Dept of Gov

We are under contract with the following who have direct Government Contracts from Department

We have established our status as "necessary" industry with District Board No of State
located at
By (Title)

Sworn to before me at
this day of 191 .

Title of official administering oath

I have checked the foregoing statements and have found them to be correct

Local Representative of Dept

Aeronautical Patents

ISSUED JUNE 11 1918

1,269,185—To Edward Hairly Mughes Canton, Ohio. Aerial torpedo.
1,269,397—To Glenn H. Curtiss, Buffalo, N Y, assignor to Curtiss Aeroplane & Motor Corp., a corporation of New York. Hydroaeroplane-pontoon.
1,269,420—To Willis A. Gibbons Flushing, N Y, assignor to The Goodyear's India Rubber Glove Mfg Co a corporation of Connecticut. Process of forming airplane structural elements.
1,269,547—To James Joseph Murray New York, N Y. Airplane.
1,269,570—To Glenn H. Curtiss Buffalo, N Y, assignor to Curtiss Aeroplane & Motor Corp., a corporation of New York. Convertible running gear for aircraft.

ISSUED JUNE 18 1918

1,269,645—To George M Robbins Newark, N J. Airplane Hydroplane.
1,269,871—To Harivig Sorley Macomb, Ill. Airplane.
1,269,872—To Harivig Sorley Macomb Ill. Propelling Mechanism for Airplanes.
1,269,873—To Harivig Sorley Macomb Ill. Carriage Structure for Airplanes.
1,269,885—To Piotr Warmuski Baltimore, Md. Observation Device.
1,270,178—To George E. Lehtinen E. Jeffrey, N H. Aeronautical Compass.
1,270,206—To Charlie Peirrsoe Florence Wis. assignor of one-fourth to Harvey Bowman Florence Wis. and one-fourth to Charles Ericson, Commonwealth, Wis. Airship.

Digest of the Foreign Aeronautical Press

L'Aeronauta, March, 1918

New Type of Observation Balloon—A new type of observation balloon has just been produced in Italy to the designs of Signor Prassone, director of the Italian Army Aircraft Works, and Major Avorio, chief of the Aerostatic Section of the Italian army

On being tested this observation balloon has given altogether much more satisfactory results than the classic Parseval-Sigsfeld kite-balloon—which cannot be safely used in wind velocities exceeding 5-6 m per second—and the various types

Mounting of a Salmson Engine in a Voisin Biplane
(C) *Kyyrie Photo Service*

that have been derived therefrom, such as, for instance, the trilobal balloon of Cacquot

Without entering into a detailed discussion of its features, it may be stated that the Prassone-Avorio balloon is essentially a spherical aerostat fitted with stabilizing means which has been calculated as an airship, and acts as a kite. Its inherent stability is of such magnitude that the balloon may be employed in winds up to 25 m per second velocity it is obvious that this feature favorably affects the stability of the basket, which, owing to its method of suspension, increases in its turn the stability of the whole system

A further advantage this balloon affords is, that for an equal load and ceiling it requires a smaller gas volume than the typical kite-balloon, thus a Prassone-Avorio of 1000 cu m capacity amply corresponds in its performance to a kite-balloon of 1200 cu m volume It follows, that owing to its smaller dimensions the P-A balloon affords greater facility for transportation and housing, and a smaller target to anti-aircraft fire, while the amount of gas required for its filling is correspondingly decreased relative to older types.

On the other hand, its lesser resistance to the wind permits to employ mooring cables of smaller section, while its ability to ascend nearly vertically increases the attainable altitude, finally the increased indeformability of the envelope permits it to effect descents at a much higher rate of speed than was possible heretofore The spherical form of this balloon as well as its considerable stability make it furthermore possible to mount defensive armament on board

It may be finally noted that, should the mooring cable snap, the Prassone-Avorio balloon may be operated as a free balloon

Flying (London), June 26, 1918

Allied Supremacy in the Air—In the matter of air work, it seems, the enemy made his last bid for equality at the beginning of the present series of offensives. Previously to the opening of March 21, he had concentrated and kept back as much air stuff and as many air pilots as could be managed, and, simultaneously with the opening of the first battle, he put in all that he could furnish

In order to keep up to something like equality, he brought forward air reserves at a rate far beyond the normal; it was a policy that brought its own punishment, for even more than in the matter of infantry or artillery reinforcements, the air forces demand their full period of training, and this business of intensified reinforcement soon brought the German air forces down to a dangerously low level of quality. It is said that pilots have been captured to whom a single loop was a thing unknown, and, whatever truth there may be in this, it is certain that enemy pilots in many cases are so inexperienced that they will not risk a fight in less strength than a three to one superiority. That is the price that temporary equality cost, a definite inability to maintain even a fairly good defensive, and the probability of being wiped out of the air altogether, save for night bombers, in the course of the next three or four months, when the accession of American strength to the Allied air forces will begin to make itself felt along the front

It was a good bid that the Germans made, away back in the days of early April enemy flyers did a good deal of damage in a legitimate way, apart from the bombing operations by machines unfitted for direct war work over the lines, as things stand at present, though, the Allied pilots hold the air, and every Hun machine that goes up flies in the knowledge that it is "up against it," and that Allied superiority is increasing

German Wind Velocity Meter
Central News Photo Service

Flight, June 20, 1918

British Air Raids on Germany—The following table shows the number of German towns raided by British airmen during May, together with the military objectives reached, and the number of times each town was raided

Place	Military Objectives	No. of times raided
Bensdorf	Station and sidings	2
Coblenz	Station and barracks	3
Cologne	Stations, factories, barracks	3
Courcelles	Station and sidings	1
Diedenhofen (Thionville)	Station and sidings	14
Esch	Station and sidings	3
Hagendingen	Railways and factories	1
Karlsruhe	Station and workshops	1
Karthaus	Station and bridges	3
Kreuzwald	Electric power station	4
Landau	Barracks, station, sidings, gasworks	2
Mannheim	Chemical factory	5
Metz	Stations and sidings	3
Metz-Sablon	Stations, sidings, railway triangle	12
Saarbrucken	Factories, sidings, sidings	6
Spittel	Station	1

News of the Fortnight

Bristol Production Discontinued

When Archer A. Landon, Chief of the Production Division, Bureau of Aircraft Production, was in Buffalo, N Y, last week, he ordered the discontinuance of the manufacture of Bristol fighting planes Later he prepared the following statement for publication

"Early last year it was decided, when the demand for two-seated fighters was great, to put into production at the Curtiss Co an adaptation facsimile of the Bristol fighter, an English battle plane, fitted to a 12-cylinder Liberty motor Recent flying tests have demonstrated that this machine is overpowered and not of military value, lacking manoeuverability, and not having sufficient speed for war purposes. Inasmuch as the DH-4 is in production and meets the requirements and can be produced as fast as engines can be supplied, so that there will be no decrease in the number of planes going over seas, we are compelled to take the position that the country will be best served by immediately discontinuing Bristol production We will make every effort to quickly put into production at the Curtiss Co the SE-5 and the Caproni. These planes are well known and are not experimental in any way We hope that we will be able, in the near future, to re-employ the people who will have to be laid off under this order"

Some such order as this has been forecast for several weeks and makes no small change in the production program, but it is judged from the tenor of Mr Landon's statement that it is proposed to make up the deficiency by an increased production of SE-5's or single seat pursuit planes, Caproni night bombers and DH day bombers and probably Handley Page machines.

It is understood that the program called for the production by the Curtiss Aeroplane & Motor Corp of 2000 or more Bristol fighting machines, and that of this order about fifty had practically been completed at the time the cancellation order was issued.

Lipsner in Charge of Air Mail

Capt B B Lipsner of the United States Army, who has been acting as assistant to Captain Willoughby, in charge of the Aerial Mail Service, resigned his military commission July 13, to accept from the Postmaster General the position as Superintendent of the Aerial Mail Service.

Captain Lipsner entered upon the discharge of the duties of his new position on July 15 He will have charge of the operation and maintenance of the new system, with head quarters at Washington

Captain Lipsner is a recognized authority on transportation and mechanical maintenance and assisted in the installation of the service He was appointed to the Army on May 25, 1917 His home, which has been in Chicago, is now in Washington

New Air Mail Record

After the there who brought the air mail from Washington and Philadelphia on July 23 had opportunity to confer with H L Hartung, in charge of the aerial station at Belmont Park and check up in consultation with the stations at Washington and Philadelphia, it was discovered that a record had been made

Mr Hartung wired the Bustleton and Washington stations and got the exact leaving time, which showed that the total lapsed time between Washington and Belmont Park, about 230 miles, was 2 hr 10 min At the beginning of the air mail service 3 hr was considered good

New American Ace

The latest American "Ace" is Lieut James A. Meissner, who was recently decorated with the *Croix de Guerre* when he brought down his fourth machine On July 8 he brought down his fifth

The standing of American "Aces" is as follows now that Lieutenant Baylies and Baer are out of action

Putnam	12
Parsons	8
Tobin	6
Campbell	6
Rickenbacker	5
Peterson	5
Meissner	5

Flying Training for Ground Officers

Maj.-Gen. W. L. Kenly, Director of Military Aeronautics, has caused this memorandum covering the instruction of flying officers of his Division.

Section A.

1 The policy of permitting non-flying officers to be trained as pilots is announced by the Director of Military Aeronautics for the purpose of building up in the Air Service *esprit de corps* by destroying the rapidly growing class distinction between the non-flying and the flying officer, and it is the firm belief that an officer who is trained as a pilot is of more value to the Air Service than one who is not trained as a pilot, even though his ordinary duties do not require him to pilot an airplane.

2 With the following exceptions the execution of the details of this policy rests entirely with the commanding officers of the various aviation stations

a No non-flying officer will be given flying instruction until after he has successfully passed the prescribed physical examination for pilot.

b The following instruction for non-flying officers must not interfere in any way with the training of cadets

c. Flying instruction for non-flying officers must not interfere in any way with the ordinary post and squadron duties of the officer

d Flying instruction for non-flying officers must be given at the convenience of the Government. It is not expected that all non-flying officers who desire flying training will be given flying training at once

It is intended that this policy will be effected gradually

Section B

1. In view of the recent change in policy of the Department of Military Aeronautics with regard to non-flying officers being allowed to take up flying instruction, it has become necessary to formulate certain rules outlining the method to be pursued in handling those non flying officers who are not allowed to fly At the present time there are non-flying officers in the Air Service who may be classified as follows:

First Men who have had no military experience whatsoever and who, due to the stress of the occasion, were granted commissions without their being given any preliminary military or theoretical course along aviation lines

Second Men who are graduates of training camps but who did not have sufficient basic military knowledge to hold the knowledge they gained while at these camps and consequently are little better off than the men who are in class one.

Third Men who are graduates of training camps but who retain some knowledge along disciplinary and military lines.

Fourth Officers of military experience who need no extra military training

2 It is quite apparent that men in classes one and two should be required to take the entire ground school course before they are sent to a flying school, while men in class three should be given some special ground school course for the purpose of educating them along theoretical aviation lines only while men in the last class could probably receive sufficient instruction along aviation lines at a special aviation school

It is to be noted that this is only a memorandum and is not regarded as a positive order and that the proposed instruction is not compulsory but rather permissible to those physically qualified non-flyers who may wish it. It may be construed as more in the nature of a request or a suggestion of what is considered desirable both for promoting harmony between the flying and non-flying personnel and also for making every man of the greatest possible value to the Service regardless of whether he may or may not ever be called upon to make practical or active use of his training As such it is believed that it should and will be complied with generally as facilities permit by officers in the fourth classifications and in the manner outlined in the memorandum

New Censor for Aeronautics

Second Lieut. F B Simond has been appointed censor in the Department of Military Aeronautics

Kellogg May Join Investigators

Before the Senate Sub-Committee on Military Affairs on July 9 and 10, Maj Cushman A Rice of the United States Air Service overseas and lately returned from France described conditions on the Western battle front.

Maj-Gen W L Kenly, Director of the Department of Military Aeronautics, was a witness on July 20 before the Senate Sub-Committee on Military Affairs. It is understood that General Kenly was called to discuss remedies for certain unsatisfactory conditions said to have been found by the committee in its investigation of the general aircraft situation, and that among them was some remedy for the many and continued casualties at the flying fields.

It is stated that the committee has practically concluded its investigation and that the preparation of its report will be begun very soon.

It is also stated that the report will charge the waste of millions of dollars in experiments with Bristol machines, that 1200 training planes produced at a cost of $6,000,000 were "scrapped", that these training planes were dangerous and caused the loss of lives of several aviators, and that responsibility for delay in production was due in part to amateurs in the Government employ and in part to the former Aircraft Board

On the other hand, it is said that report will show that production under the Bureau of Aircraft Production shows greatly improved conditions, and that the Liberty engine is a complete success.

The scene of the aircraft investigation by the Department of Justice has been moved from Washington to Western manufacturing centers The first hearing was at Dayton, Ohio and it is understood that other hearings will be held at Detroit, Toledo and several cities

It is reported that N W Kellogg, an attorney of national reputation as an investigator, has been called in to assist the official of the department and Judge Hughes, the special investigator

Russian Expert on N. A. C.

Dr Georges de Bothezat, of Petrograd, has been engaged by the National Advisory Committee for Aeronautics, Washington, D. C., as an adviser in aeronautics. Dr Bothezat was lately professor of applied mechanics and aerodynamics in the Polytechnic Institute at Petrograd and enjoys international reputation as an investigator of aerodynamics. He has also acted as a consulting and designing engineer to Russian aircraft factories.

New American Combat Plane

According to the Philadelphia *Public Ledger* Bureau, the Curtiss Aeroplane Co has just completed a combat triplane fitted with a 400 hp engine which shows unusual climb and speed.

Army and naval officers who have seen the machine in tests are reported to be most enthusiastic over its possibilities It carries two passengers and is equipped with two machine guns.

Castor-Bean Growing in Siam

The castor-oil plant grows wild in almost every part of Siam, but hitherto it appears that no attempts have been made in its cultivation However, an extensive plantation has now been started by a Bangkok merchant who expects to harvest about 1000 tons of the seeds within five or six months after the planting, which is now in progress. It is the intention of this merchant to produce the oil on the premises.

Standard Increases Capital Stock

The Standard Aircraft Corp announces an increase in capitalization from $5,000,000 to $10,000,000, divided in $7,000,000 preferred, and $3,000,000 common stock, all subscribed and taken. This has become absolutely necessary, in order to take care of the enormously increased production of the organization which, although but two years old, is now a predominant national figure in aircraft production. Of the preferred stock, $1,000,000 will, for the present, be retained in the company's treasury

The officers of the company are Harry Bowers Mingle, president, Edward E Pennewill, vice-president and general manager, Max J Finkelstein, vice-president and treasurer, and Charles H Day, vice-president and consulting engineer.

Airplane Spruce Contingent

Provost Marshal General Crowder has issued a call for an additional 3000 men from thirty-eight states to produce spruce in the forests of the Northwest for airplane construction. From Class 1 only men who are qualified for special or limited service will be accepted

These, as well as registrants in the second, third and fourth classes qualified for general military service, were permitted to volunteer until July 23, but after that date sufficient men will be selected from Class 1 to make up any deficiency in a state's quota.

450 American Battle Planes Ready

Four hundred and fifty American built battle planes had been sent abroad or delivered at ports for shipment on July 5, the date of the latest complete official report reaching the War Department.

In announcing this figure, July 15, Secretary Baker disclosed also that deliveries of Liberty engines of all classes on the same date had reached 2,514

To Inspect U. S. Air Stations Abroad

Chairman Padgett and other members of the House Committee on Naval Affairs will leave on a battleship to make a tour of inspection of the naval activities in the European war zone Secretary Daniels has approved the plan of the trip and will detail an officer to accompany the party and make the arrangements. The committee will visit England and France where there are United States air stations of various kinds installed and maintained by the Navy The party will be away five or six weeks.

Victor Aircraft Corporation

The A S Heinrich Corporation of Freeport, L. I., N. Y., has just changed title to the Victor Aircraft Corporation The officers of the company remain the same

A Rust Proofing

The increased cost of galvanizing and other processes of rust-proofing and the unsuitability of galvanizing or other metal as a coating for metal parts which must be inspected rigidly for defects before assembling and constantly reinspected during use, has turned attention strongly to the satiny transparent, rust-proof and acid-proof finish which has been developed by the Enameling & Stamping Corporation of New York It is said that no defects in metal can possibly be concealed by it when baked in its transparent form Various Government and airplane manufacturers are carrying out tests of this finish As a priming finish it grips the pores of the metal so closely that no scraping or cutting can alter the rust-proof effect, unless the metal itself is cut away The rust-proof finish also is being applied in many cases with pigment, of all colors, in it As it costs considerably less than porcelain enameling, it is expected to displace that finish for many articles It is, in fact, less expensive than galvanizing or tinning under present conditions.

Barthel Joins Curtiss

T E A Barthel has become associated with the Curtiss Aeroplane & Motor Corp of Buffalo, N Y, with duties connected with the finances of the organization Mr Barthel was formerly president and general manager of the King Motor Co. of Detroit

Uncle Sam's Wars

The Widney Co, 320 S Jefferson St., Chicago, Ill., manufacturers of advanced felt specialties, has recently issued an interesting booklet called "Uncle Sam's Wars." It is a thirty-two page booklet, and gives all of the wars since the Revolutionary contest in which we have participated, together with photographs of the war presidents.

American Bronze Corp. Builds Addition

Owing to the increase in the demand for Non-Gran Bearing Bronze, the sole product of the American Bronze Corp., at Berwyn, Pa., a large addition to its works has been constructed and will be completed about August 1 This new plant is of fireproof factory construction, and will triple the concern's present capacity.


Heat Control

Above picture shows a shipment of Walnut Logs received by the Hartzell Walnut Lumber Mills

LIBERTY PROPELLERS

FROM THE LOG TO THE FINISHED PROPELLER BLADE

For many years the Hartzell Walnut Lumber Mills have been among the largest in the world. With our fine connections already established in the best sources of original supply, it was but natural, when the need was shown, that we should turn some of our excellent native Walnut into finished Airplane Propellers. Our large and splendidly equipped Propeller plant is the result. Here we turn out complete and in quantities the Liberty Propellers. New, modern and extensive equipment, the right material and plenty of it, coupled with experienced and careful workmanship, enable us to offer Airplane Manufacturers the Walnut Propeller of supreme quality—the LIBERTY.

HARTZELL WALNUT PROPELLER CO. · PIQUA, *OHIO*

Thomas

THOMAS-MORSE AIRCRAFT CORPORATION

ITHACA, N.Y. U.S.A.

Contractors to U. S. Government

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Propeller Shaping Machine

For Two, Three and Four-Bladed Screws

A brand new machine—designed and built with the thoroughness characteristic of all Mattison woodworking machines—which has been approved by many of America's largest propeller manufacturers.

It works close to finish-size, thereby eliminating the greater part of the expensive hand work which usually follows the machining operation of other methods.

Write or Wire for Details

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THE DEFIANCE AUTOMATIC AIRPLANE PROPELLER LATHE

IT HAS GOVERNMENT AND MANUFACTURERS' ENDORSEMENTS

The proof of this lies in its use in England in Italy, in Canada, its use in United States Government Arsenals, and fifteen of the leading propeller factories in America. Each machine in use releases from eight to ten skilled workmen for other duties. With one man operating a number of machines, the cost of working propeller blades close to size is reduced to a minimum. It automatically turns propeller blades of various sizes to any shape or pitch, and it will duplicate struts of irregular shape in facsimiles. Write for our circular which illustrates and describes this machine

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are now being given exclusive and intimate expression through the

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The Association was organized within the service, by flying officers, who elected their own officers, and its membership is made up of the men who are fighting and will fight our air battles.

In addition to the established editorial features of AIR SERVICE JOURNAL—all the news of the Air Services each week, foreign aeronautical news, notes of the flying fields and ground schools, Air Service orders, special articles on aeronautical subjects, and photographs of aerial happenings all over the world—it will feature exclusive articles by officers of the Air Services through the editorial board of the Air Service Association.

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The only core that will stand severe landing shocks.

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Aeronautical Trade Directory

AVIATION AND AERONAUTICAL ENGINEERING will furnish information and addresses of companies listed below.
Names of Advertisers in this issue are printed in capitals.
See Index to Advertisers on page 66

ACCESSORIES AND INSTRUMENTS

Advance Felt Specialty & Cutting Co
INTERNATIONAL AERONAUTICAL INSTRUMENT CORP
JOHNS-MANVILLE H W CO
Ging, Jalion, Optical Co.
THE MOTO-METER CO
National Gauge & Equipment Co.
Nelson Blower & Furnace Co
O'Hara Waltham Dial Co.
Queen Gray Co
Sloker, Welrer
SPERRY GYROSCOPE CO
Standard Aeronautical Co
Stewart Warner Speedometer Corp
TAYLOR INSTRUMENT COMPANIES
Veedrr Mfg Co
Western Electric Co.

AIRPLANES

Aeromarine Plane and Motor Co.
Blackhawk Airplane Co.
BOEING AIRPLANE CO
Breese Aircraft Corp.
THE BURGESS COMPANY
California Aviation Co
CONTINENTAL AIRCRAFT CORP
CURTISS AEROPLANE & MOTOR CORP
Dayton Wright Airplane Co
Des Lauriers Aircraft Corp
Dewey Aeroplane Co.
Engel Aircraft Co.
Fisher Body Corp.
Fowler Airplane Corp
Gallaudet Aircraft Corp
Heinrich A. S. Corp.
LANZIUS AIRCRAFT CO
Lawrence-Lewis Aeroplane Co.
Lawson Aircraft Corp
Lewis & Vought Corp.
LOENING AERONAUTICAL ENG CORP
Longren Aeroplane Co.
L. W. F. ENGINEERING CO
MARTIN GLENN L. CO
Michigan Aircraft Corp.
ORDNANCE ENG'RING CORP
Patterson Aeroplane Co
Peirce, Sam'l S. Aeroplane Corp.
Smith, Kyle, Aircraft Co
Sperry, Lawrence, Aircraft Co
Springfield Airplane Co.
STANDARD AIRCRAFT CORP
Sturtevant Aeroplane Co.
THOMAS-MORSE AIRCRAFT CORP
The Willys-Morrow Co
WITTEMANN LEWIS AIRCRAFT CO
Whittemore-Hamm Co
Wright Martin Aircraft Corp.

AIRPLANE ENGINES

Aeromarine Plane and Motor Co
Ashmusen Mfg. Co.
Continental Motors Co.
CURTISS AEROPLANE & MOTOR CORP
Dayton Aero Motors Co.
Detroit Gas Turbine Corp.
DUESENBERG MOTOR CORP
General Ordnance Co.
General Vehicle Co.
Gyro Motor Co.
HALL-SCOTT MOTOR CAR CO
Kemp Machine Works
Kessler Motor Co.
Knox Motors Co.
Nordyke & Marmon.
Packard Motor Co.
Roberts Motor Mfg. Co.
Rolls-Royce, Ltd.
Springfield Motors Co
Sterling Engine Co
Sturtevant, B F, Co.
Trego Motors Corp
THOMAS-MORSE AIRCRAFT CORP
UNION GAS ENGINE CO.
Van Blerck Motor Co
Willys-Overland Co
WISCONSIN MOTOR MFG. CO.
World's Motor Co.
Wright Martin Aircraft Corp

AIRPLANE PARTS

Aircraft Parts Mfg. Co
American Body Co
ASTORIA VENEER MILL & DOCK CO
BARCALO MFG CO
Century Telephone Construction Co
Chicago Aeronautical Supply Co.
DAYTON METAL PRODUCTS CO
ERIE SPECIALTY CO.
GENERAL BAKELITE CO
HOLBROOK CO
KAWNEER MFG CO
Levett, Walker M Co
New Jersey Veneer Co
Pressed & Welded Steel Products Co
Rogers Construction Co
Standard Parts Co.
Welch Mfg Co
Whittemore-Hamm Co.
WIDMAN J C., & CO.
Willys Morrow Co
Wilson Cabinet Co

ALUMINUM

Arteral Co of America
Aluminum Castings Co.
ALUMINUM CO OF AMERICA
American Metal Co., Ltd.
Levett Walker M., Co.
LEGRAND & CO
McAdamite-Aluminum Co.
SO-LUMINUM MFG & ENG CO. (SOLDER)
STIMPSON, EDWIN B. CO.
United Smelting & Aluminum Co.

AVIATION SCHOOLS

American School of Aviation
America Trans Oceanic Co.
Atlantic Coast Aeronautical Station
Beam Airplane Co
Blackhawk Airplane Co.
Curtiss Training Schools
EAGLE AVIATION SCHOOL
The Hydroaircraft Co.
Michigan State Auto School
Meier Aviation Instructors
Penn. State School of Aero-Mechanics
Stinson School of Aviation
Whittemore Hamm Co

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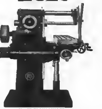
FOX



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NEW DEPARTURE MFG CO
Norma Company of America
S. K. F. Ball Bearing Co
U. S. Ball Bearing Mfg. Co.

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Connecticut Aircraft Co.
Custer Specialty Co. (Statoscope)
Gas Engineering Co. (Gas Plants)
GOODYEAR TIRE AND RUBBER CO
United States Rubber Co.

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INTERNATIONAL AERONAUTICAL INSTRUMENT CORP
Sossfeld & Lorch
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FAHRIG METAL CO
Lovell Walker M., Co
Magnolia Metal Co

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American Bronze Corp
Bound Brook Oil-less Bearing Co.

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Miller Carburetor Co.
Stromberg Motor Devices Co.
Wheeler & Schebler
ZENITH CARBURETOR CO.

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Chelsea Clock Co
Depollier, J. & Son
Hamilton Watch Co
Ingersoll, Robert H., & Bros.
Waltham Watch Co.

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Cross, Mark
N. Y. Sporting Goods Co
Rainwear Co
Rogers, Peet & Co.
Sanders Company
Spalding, A. G., & Bros.

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Star Compass Co.
TAYLOR INSTRUMENT COMPANIES

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American Emaillite Co
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CHEMICAL PRODUCTS CO.
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DU PONT CHEMICAL WORKS
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Howe Varnish Co
Lucas, John, Company
Masury, John W., & Son
Perry Austen Company
PRATT & LAMBERT
SHERWIN WILLIAMS CO
Smith, Edward, & Co
Standard Varnish Works
VALENTINE & COMPANY
Weeks & Co

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SPERRY GYROSCOPE CO

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DYNAMOMETER
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Fibre Finishing Co.
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Meisel Press Mfg Co
PARK DROP FORGE CO
Pressed & Welded Steel Products Co
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Pyrene Mfg. Co

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Crosby Steam Gauge & Valve Co.
FOXBORO CO. INC
Greenfield Tap & Die Corp.
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GASKETS
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Booth Felt Co.
Fibre Finishing Co.

GLUE
Armour Glue Works
Border & Adamson
Fredlund L. W. & Co
WIDMAN, J. C., CO

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Aeronautical Trade Directory—*Continued*

GOGGLES

Hardy, F A Co
Meyrowitz, E B.
STRAUSS & BUEGHLEISEN
Strong, Kennard & Nutt
Triplex Safety Glass Corp.
Willson, T A., & Co., Inc.

HANGARS

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Anchor Corrugating Construction Co.
Ashley Steel Bldg Co.
Austin Co., The
Barney, John M.
Hazell, Field & Goddard, Inc
Kossby & Mattison
Milliken Brothers
Pruden, The C. D., Co.
Steel Fabricating Co., The
Virginia Bridge & Iron Co.

HOISTS

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IGNITION

PHILLIPS BRINTON CO THE

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Universal Safety Mattress Co

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American Balsa Corp
ASTORIA VENEER MILLS & DOCK CO
Chatham Lumber Co
Delatour J
Dutton, A. C., Lumber Corp.
Ludlow Israel
Mengel C. C., & Bros. Co.
New Jersey Veneer Co.
Sheip & Vandergrift

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Cummings W L., Chemical Co
RADIUM DIAL CO
RADIUM LUMINOUS MATERIAL CORP

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DEFIANCE MACHINE WORKS
FOX MACHINE CO.
Warner & Swasey Co.

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DEFIANCE MACHINE WORKS
Fay J A & Egan Co
FOX MACHINE CO
Machinery Merchants, Inc
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Olney & Warrin
PRYIBIL, P., MACHINE CO
YATES P B MACHINE CO

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Bosch Magneto Co
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Remy Electric Co.
Splitdorf Electrical Co

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Pressed & Welded Steel Products Co

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AMERICAN BRONZE CORP.
American Vanadium Co.
Bethlehem Steel Co.
BETZ-PIERCE CO., THE
BLUM, JULIUS & CO.
Detroit Pressed Steel Co.
Federal Pressed Steel Co.
Garland Ventilator Co.
Gueder Paeschke & Frey Co.
KAWNEER MFG CO
La Salle Steel Co
Levett Walker M., Co.
Rumford Metal Co.
SO-LUMINUM MFG & ENG CO
Standard Alloys Co
Steel Sales Corp.
STEEL PRODUCTS CO
STIMPSON, EDWIN B., CO
Wheeler, Frank H., & Son

MODEL AIRPLANES

Ideal Aeroplane Supply Co.
Wading River Mfg. Co.

MOTORCYCLES

Excelsior Motor Mfg. Supply Co.
HENDEE MFG CO
Harley Davidson Co.
Militaire Motor Vehicle Co. of America

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Graphite Lubricant Co.
Gulf Refining Co.
Sheppard Ideal Oil Co.
Soo Co The
Standard Oil Co.
Swan & Finch
Texas Co., The
Vacuum Oil Co
WAKEFIELD C C & CO., LTD

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Advance Felt Specialty & Cutting Co
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Lang Propeller Co of America
Steven Sash & Door Co
Reinforced Propeller & Insulating Co The
United States Aero Propeller Co
Washington Aeroplane Co
WEST WOODWORKING CO

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Aeronautical Trade Directory—*Continued*

PYROMETERS
FOXBORO CO., INC., THE
Moto-Meter Co
Shore Instrument & Mfg. Co.
TAYLOR INSTRUMENT COMPANIES

RADIATORS
AJAX AUTO & AERO SHEET METAL CO.
A-Z Co.
Bush Mfg. Co
El Arco Radiators Co.
English & Mersick Co.
FLEXO MFG CO
Harrison Radiator Co
Livingston Radiator Co
McCord Mfg. Co.
ROME TURNEY RADIATOR CO
STANDARD ROLLER BEARING CO.

RIVETS
STIMPSON EDWIN B. CO.

SCELEROSCOPE
Shore Instrument & Mfg. Co

SHEET METAL FITTINGS
BLUM JULIUS & CO.
Rogers Construction Co

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Doral Rubber Corp
General Rubber Goods Co.
RUSSELL MFG CO
WOOD, J. W., ELASTIC WEB CO.

SPARK PLUGS
Bosch Magneto Co
Champion Ignition Co
JOHNS-MANVILLE, H W., CO
Rajah Auto Supply Co.
Silvex Co. The
Splitdorf Electrical Co.

SPEED INDICATORS
FOXBORO CO. INC.
JOHNS-MANVILLE, H W CO
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Martin Aerodynamic Stabilizer
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ENAMELING & STAMPING CORP OF NEW YORK
LANSING STAMPING & TOOL CO.
Dewes Co., The A
STIMPSON, EDWIN B., CO

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Bijur Motor Lighting Co.
Bosch Magneto Co.
CHRISTENSEN ENGINEERING CO THE
Dayton Engineering Laboratories Co.
MOTOR-COMPRESSOR CO.
Northeast Electric Co
Remy Electric Co
Wagner-Hoyt Electric Co.

TANKS
Janney, Steinmetz & Co.

THERMOMETERS
FOXBORO CO., INC., THE
MOTO-METER CO
TAYLOR INSTRUMENT COMPANIES.

TIRES AND RUBBER
Doral Rubber Corp
GOODYEAR TIRE & RUBBER CO.
Hodgman Rubber Co.
United States Rubber Co.
WOOD, J W., ELASTIC WEB CO
Whitley Exerciser Co.

TOOLS
American Tool Works Co.
Bass Brothers
BLUM JULIUS & CO
BROOKS MACHINE CO
Brown & Sharpe
Buffum Tool Co
Cooper Aeroplane Co., The John D
HALL-SCOTT MOTOR CAR CO.
HAMMACHER, SCHLEMMER & CO
LANSING STAMPING & TOOL CO
Peck Stowe & Wilcox Co.
Rich Tool Co.
Rogers Works, John M
Smith & Hemenway
WHITMAN & BARNES MFG. CO.

TRUCKS AND TRAILERS
Federal Motor Truck Co.
Four Wheel Drive Auto Co
Fruehauf Trailer Co
Nash Motors Co.
Packard Motor Car Co.
Sechler Company, The
Service Motor Truck Co.
White Company The

TUBING
American Tube Co
BLUM, JULIUS & CO.
Dewes Co., The A.
Empire Art Metal Co.
Frasse & Co., Peter A.
National Tube Co
PENNSYLVANIA FLEXIBLE METALLIC TUBING CO
STIMPSON, EDWIN B., CO.

TURNBUCKLES
Aero Mfg & Accessories Co
DAYTON METAL PRODUCTS CO
Dillner-Meyer Mfg. Co.
SHIE SPECIALTY CO.
National Aeroplane Co.
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STANDARD TURNBUCKLE CO
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ACKERMAN WHEEL CO
Dayton Wire Wheel Co.
Hayes Wheel Co
Moll Wheel Works
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Watson Wheel & Rim Corp.
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Electric Cable Co
NEW YORK WIRE AND SPRING CO
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ROEBLING'S SONS, JOHN A.
Simplex Wire & Cable Co.
Upson Walton Co.

WIRELESS
American Radio & Research Corp.
American Wireless Telegraph Co.
Colting & Washington, Inc.
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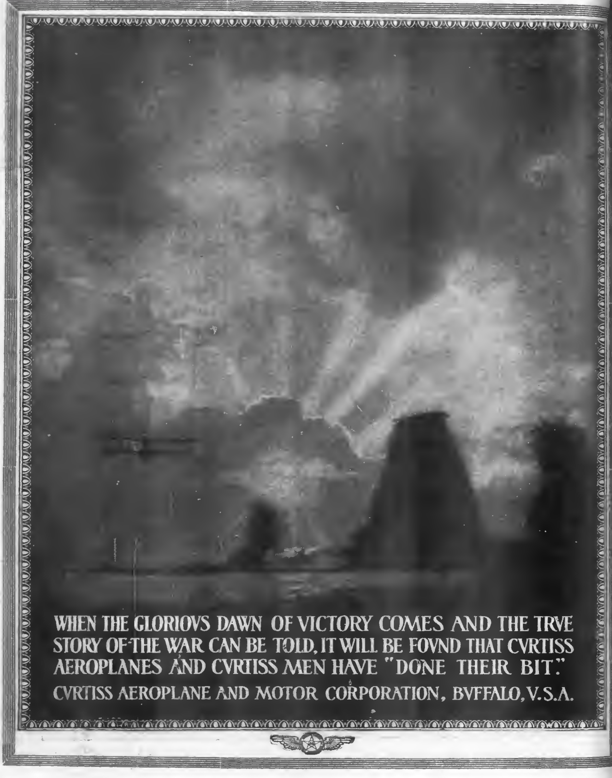
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